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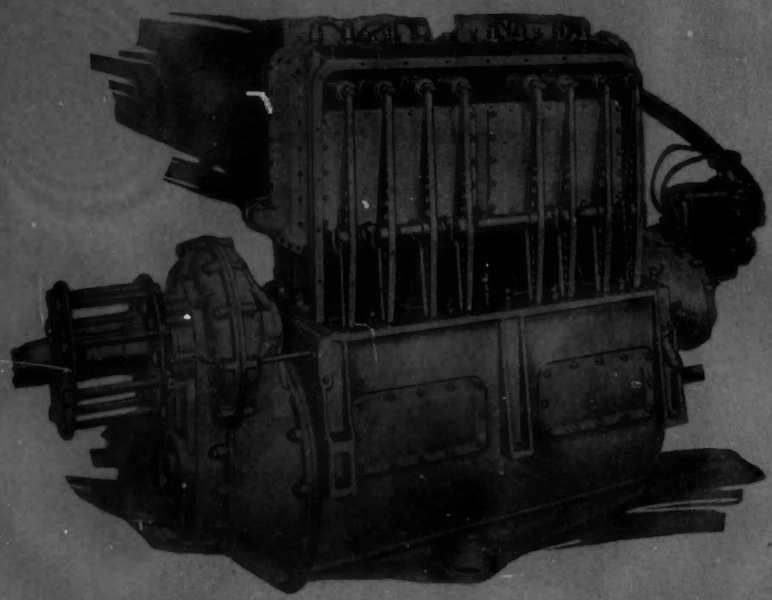

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THE JOURNAL OF THE SOCIETY OF AUTOMOTIVE ENGINEERS

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The FREMONT TRACTOR MEETING OF THE SOCIETY

THAT the tractor industry as a whole is thoroughly in support of the activities of the Society was shown by the assemblage of engineers and executives in attendance at the meetings held Aug. 5 and 6 at Fremont, Neb. The Masonic Hall was filled to overflowing both at the dinner and professional session held on the 5th and at the service session held on the following evening. The complete addresses, technical papers and discussions are given in practically complete form elsewhere in this issue. A meeting of the Tractor Division of the Standards Committee was held on both days at the Hotel Pathfinder, Fremont, and resulted in an endorsement of the work already recommended by the Division and in a large number of tractor subjects being suggested for immediate standardization.

Although the first S. A. E. meeting did not take place until Wednesday, many members of the Society attending the Tractor Demonstration registered Monday and Tuesday at S. A. E. Headquarters. Through the courtesy of the Fremont Commercial Club the members were guests at a number of enjoyable social affairs given during the week for the visiting tractor men. On Monday evening they were welcomed by the mayor of Fremont, President Wolz of the Commercial Club, President Bartholomew of the National Tractor and Thresherman's Association, and Chairman David Beecroft of the Meetings Committee of the Society. This was followed by a buffet supper served in the basement of the Pathfinder. On Tuesday evening an entertainment was given at the Masonic Hall and on Thursday evening the visitors were treated to a watermelon festival immediately after the conclusion of the Tractor Service Session.

On Wednesday evening nearly four hundred members and guests of the Society, after partaking of the homelike dinner served by the ladies of Fremont, were called to order by President George W. Dunham, who delivered an address entitled, The Future of the Farm Tractor Industry. President Dunham analyzed the relation of the farm tractor to the production of foodstuffs, and showed the need for the immediate production in large quantities of farm tractors. He urged the interchange of ideas so as to improve the quality of the product and thus secure to the tractor industry a position it potentially deserves.

The first paper of the evening was given by Arnold P. Yerkes, who discussed the size of farms on which tractors can be used profitably and gave figures indicating that the percentage of farms ranging from one hundred acres upward had increased in the years between 1900 and 1910, and that farms of from one hundred to four hundred and ninety-nine acres would probably be the heaviest users of tractors. As a result of inquiries made by the Office of Farm Management, Mr. Yerkes stated that the four-plow tractor is the most efficient size, all things considered.

The methods of using kerosene in farm tractor engines were reviewed by W. G. Clark, who gave an account of experimental work done in determining the best method of obtaining proper low-grade fuel mixtures. He said that engines must be designed to take care of the higher operating temperatures of kerosene and mentioned a number of important things to be considered in such design.

The final event of the evening was an address by Past-President Howard E. Coffin, who spoke of the work being done by the Council of National Defense. He mentioned briefly the standardization activities connected with aircraft, motor truck, tractors and other forms of automotive apparatus, and stated emphatically that industry must play the vital part in the present world conflict. According to Mr. Coffin, the welfare of the country rests largely on the building of the greatest possible number of good tractors. In order to do this, good tractors must be built by a large number of manufacturers, and it will be to the benefit of all to interchange ideas so as to secure such a result. He also said that the tractor standardization work must be advanced rapidly, particularly as regards the specifications for materials and points of minor designs.

At the Tractor Service Session, Thursday evening, the papers delivered were unanimous in urging that steps should be taken to secure more intelligent operation of tractors. The introductory paper of the evening was presented by Dent Parret, who urged that the farmer and the manufacturer should each do his full share in improving tractor operation and thus helping to solve the nation's food problem. H. C. Buffington suggested that the Government organize departments of tractor service in each state and employ experts for the purpose of helping the farmer to operate tractors efficiently. L. B. Duntley described the organization and duties of a tractor service department. Fred. P. Steele said that service consisted in giving the maximum care to the product in the hands of the consumer at as low a cost to him as possible.

George T. Strite explained the importance of immediate tractor standardization, and told of the work now being done by the Minneapolis Section of the Society in suggesting subjects for standardization to the Tractor Division of the Standards Committee. S. B. Turkenkoph compared tractor and automobile operation and showed that the severe service required of tractors made it necessary for their owners to have complete knowledge of tractor care in order to operate them successfully. E. L. Woods outlined the obligation the manufacturer has in tractor service. This consists in having repair parts and competent service men quickly available (the latter to be paid for by the owner), and periodical visits by service men so as to help owners operate their machines efficiently.

Future of the Farm Tractor Industry

By PRESIDENT GEORGE W. DUNHAM

ON the fourteenth of last February at Kansas City was held the first dinner of the tractor engineers of the Society of Automotive Engineers. Since that time the tractor industry has been brought face to face with a responsibility of a magnitude and world-wide importance such as few if any others have had to meet.

The farm tractor must come forward and do the major part toward increasing the world's output of food products made necessary by the European war.

Many unusual demands of stupendous proportions have been thrown upon the resources of our country. One of the greatest of these is the solution of the problem of quickly and materially increasing our crop output. This is a problem of not only vital importance, but great complexity and many angles. View it as we may, the following brief analysis holds good in the relationship of the farm tractor to the production of foodstuffs.

From the situation as it existed in normal times the first step and the one from which quickest results can be obtained is the conservation of food by the elimination of waste and unnecessary consumption. This presents the same ultimate result as a corresponding increase of production.

More intensive cultivation is probably the second most simple step to be taken, as it does not entail expansion but does require more aggressive working of the land already available. It means that the land must be better prepared, prepared at the proper time, and receive greater attention in many cases through the entire season.

Then comes the increase of acreage planted, usually meaning the breaking and preparing of new lands, the hardest work in the various stages of soil development.

Many other things enter into the problem, such as distribution of labor, hauling of the product, and educational work to be done in connection with every phase.

From every angle the tractor is a prime essential. It permits the saving of foodstuffs now being grown and used for animal consumption. More tractors are obviously necessary when more intensive cultivation is attempted. When the acreage to be cultivated is increased materially an enormous demand for more power is at once created. Tractors will be used in many cases in handling the product from the field to the cars; it is known that power farming has a stimulating effect on labor conditions.

This is the situation, whether the war shall continue for several years—and I cannot conceive its end to be in sight—or peace should be declared tomorrow. The food output of this country must be increased promptly to an enormous extent, and this entails the use in great quantities of the only power device that can be produced quickly, the farm tractor.

When definite aggressive steps shall have been taken by Congress in connection with the food problem, the Government must get back of the farm tractor industry and give it an impetus such as no business has ever received. The world is in danger of starvation conditions, inconceivable as this is to us now, and our tractor manufacturers must play one of the most important parts in the carrying out of the remedy.

An analysis of the production and distribution of tractors develops a peculiar set of conditions. The number of tractors available at the present time is but a small percentage of those that could be used to advantage, even in normal times.

On the other hand, were the number available increased greatly in the immediate future, it is questionable whether all the product could be sold. Great strides have been made in the development of the tractor, so that when properly operated and maintained the average machine will do good work; any operator who understands his machine, uses it intelligently and keeps it in good condition will usually get excellent results, but because he is not properly schooled in only too many cases, the results obtained are not satisfactory and the tractor is blamed.

In this condition the determining factor is not so much that the selling organization of the tractor industry is not adequate, as that the farmer does not yet accept the tractor. There is need in this country today for thousands of tractors, but the farmers in general are skeptical and must be shown. The farmer who has accepted such tractor equipment, has, many times, received it without being properly instructed in its use and application, so that too often dissatisfaction is the result.

Salesmen have taken a derogatory attitude in regard to their competitors' product and have made such impossible claims in regard to their own, that the average farmer today has the idea that all tractors are far from what they should be.

There is such a diversity of construction of tractors that it is not inconceivable that, after looking at the different makes of entirely different types, the farmer becomes bewildered and decides that the problem of which tractor to buy is too great to be solved and that it would be better to stick to his horses.

It is of course obvious that there is need for an enormous number of tractors. Every manufacturer knows that in spite of this tractors cannot be sold in quantities necessary to meet requirements for foodstuffs. When we come to appreciate this and eliminate the cause a big step in advance will have been made. The manufacturers should educate the owner, stop knocking each others' goods and get together on types of construction.

The types of construction—and there may be two or three, for specific purposes—are bound to become similar, and the more quickly this is brought about, the sooner will the problems of manufacture, selling and service be simplified. When the operation and care of all machines become similar so the owner of one machine can properly handle any other make, and can help educate the new operators, then and not until then will this potentially great tractor industry blossom out and tractor manufacturers will begin to arrive.

The individual touch is all right in regard to general appearance, proportion or parts, or some particular detail, but the general type of construction is a thing that must be developed by the industry at large and the sooner this is accomplished the sooner it will react to the benefit of all.

The automobile has already passed through this stage, until, without any concerted action being taken by the makers at large, the modern automobile is so much of a type that with the ear-marks removed it is difficult for the novice to tell one from the other.

It may be argued that the conditions surrounding the tractor and the automobile are entirely different, but be this as it may, tractors, whether wheeled type, caterpillar type, whether the tools be drawn or are part of the tractor, can be considered similar in regard to the fundamentals.

Millions of dollars have been expended and the best efforts of thousands of the best mechanically trained intellects in the world have been employed in producing a satisfactory type of what we now know as the automobile. After long years of experimentation and experience all these intellects have found that this type presents the best solution of all the problems of construction, the most accessible and suitable arrangement of parts, and one that breaks up into units most economical to manufacture.

It has been suggested that a committee be established to standardize the tractor, as a type, but this is impracticable, for it is only by the close knitting together of the entire industry on a basis of "boost the tractor" that the unity of type can be evolved. However, much good is already being done by the Tractor Division of the S. A. E. Standards Committee in the standardization of such matters as power rating, belt and plowing speeds, height of hitch, tractor drawbar, clevis, carbureter flanges and punching of wheel rims.

It is common knowledge that the war has advanced the art of aeronautics many years. It must not be overlooked that the war is also advancing the farm-tractor art with rapidity, although not in so spectacular a manner. Each manufacturer should feel it his duty to get together with all other manufacturers, using every effort to launch a big educational movement, eliciting the support of the Government as well, so that greater advantage can be taken of the power now available, and the way properly prepared for the absorption of a greater future production.

No opportunity should be lost to cooperate and interchange efforts and ideas to the greatest extent. In fact, definite steps must be taken to bring the various makers more closely together, as to type, to improve the quality of the product and to encourage competitive performance. No doubt the war is accomplishing much, although this is not generally recognized. How much more quickly can the industry be advanced if every one will recognize the evolution through which we are now passing and take energetic steps to further it.

Always bear in mind that the tractor industry holds forth wonderful possibilities, but that this, like any other industry will never be at its best until all of us are working shoulder to shoulder.

Some Problems of National Defense

By Past President Howard E. Coffin

ABOUT a year ago, in June, there was born the idea of the society of automotive engineers, that is, a combination of the engineering work of all of the activities of the country employing the internal-combustion engine as a fundamental. This has led to the incorporation under the name of the Society of Automotive Engineers of those engineering activities relating to the tractor, aircraft, the motor boat, the automobile, the motorcycle, and the stationary gas engine.

All of these subjects are of vital interest to the cause of national defense. The reason H. L. Horning is not at this meeting is because he is leading some fifty of the foremost truck designers of the country in a night-and-day effort, in Washington, to develop a standard war truck which sooner or later shall become the accepted truck of the War Department in all military operations, and which will tend to simplify the problems of military transportation behind the firing line.

It is the desire to have the trucks used for the military service so far standardized that the repair problems will be simplified, and that the number of mechanics required to maintain the service in active operation will be reduced to the minimum.

During the past few weeks another group of the automotive engineers has been employed in Washington in developing a standardized line of engines for aircraft work, and to give some idea of the problems confronting this particular group I need only call attention to the fact that in order to develop engines probably seven times as powerful as any exhibited in a tractor today they have been called upon to design an engine that will weigh about one-third as much as the tractor engines.

These engines will probably rank with the best in the world today, although we have not been under the spur of three years of war, as have the engineers of foreign countries.

Many of those here have gone through the development of the automobile industry. Others are now launching into the development of the tractor industry. We are also deep in the development of the aircraft industry. It has not often in the history of the world been given to engineers to live through the development of three great industries as these either have become, or will certainly become, within the next few months.

The automobile builders, back in 1901 and 1907, were in much the same relative condition as are the tractor

manufacturers today. They were going through the developmental stages of the industry. There was very little cooperative work between them as manufacturers, and even less between the engineers, each engineer feeling that he must carefully guard his own secrets and his own developments, and if possible prevent his fellow engineers from learning anything about what he was doing.

Developmental Stage of Industries

This stage, I think, is inevitable in the early days of any industry. The manufacturers have gone through it, and are going through it in the tractor industry. The aircraft industry is now going through it, or was going through it a few months ago.

In the automobile business the engineers finally became acquainted through the efforts of certain far-seeing men who early in the business more or less were placed in a position to control. Having once got well acquainted, they found they were all pretty decent fellows, after all, and soon began to exchange ideas and to arrive at some real cooperation in the work of developing the industry.

The welfare of every one in the automobile business, and the welfare of every one in the tractor business, is tied up in building for the American people the maximum number of good automobiles or good tractors. There is not the least bit of advantage to the industry if some one of the builders or engineers in the industry can build the best tractor in the business, and have all the other manufacturers in the business building poor tractors. The welfare of the industry as a whole is, after all, the welfare of the individual, and the welfare of the industry as a whole, and therefore of the individual, is tied up in the accomplishment of building for the people of this country the greatest possible number of good tractors.

Consequently, everything that any one of us does to help a fellow manufacturer who may be having troubles, or who may not be building as good a tractor as we are, will sooner or later rebound to the benefit of the entire industry. A poor tractor in the hands of a farmer is about the worst kind of an advertisement any of us can have, whether it is our own particular tractor or some other fellow's.

I heard today, on the Tractor Demonstration field, a good deal of the same sort of talk about patents that we heard in the automobile business, and that we were hearing three months ago in the aircraft business. One manufacturer said: "I've got the best tractor here, and no one can build such a tractor, because I control the basic patents that govern it."

I wonder what the patents are really worth! We in the automobile business have made up our minds that patents do not amount to much. We have stopped fighting over patents and are concentrating all our efforts on building good automobiles. That is exactly what the manufacturers in the tractor business ought to be doing and soon will be doing.

In the aircraft business, three months ago, the leaders in the business were fighting over patents. Tremendous royalties were being discussed, and some were being collected from the United States Government.

One of our first steps in straightening out the problems of the aircraft industry, in which the Government is vitally interested from the standpoint of national defense, was to settle once for all the patent quarrels among the manufacturers. Within the last sixty days aircraft manufacturers have signed a cross-licensing agreement similar to that signed by the automobile manufacturers some three or four years ago, which removed once for all any possibility of patent litigation from that industry.

Now, I take it that the tractor men here are more interested in building and marketing good tractors, and in seeing their competitors build and market good tractors than they are in starting patent litigation among themselves, which would result that a good share of their profits go to the gentlemen of the legal profession who will always assure them that they have a "ground-hog" case, and can put it all over on the other fellow. I think that the history of most industries that have engaged in excessive patent litigation bears out the truth of that statement.

It is absolutely necessary to make the fastest possible time in tractor standardization work as related particularly to the specifications of materials and to the points of minor design.

By "points of minor design" I mean all such minor details as do not demonstrate the particular ability or the inventive genius of the engineer, but simply take up time in work which might just as well be standardized, and thus enable the engineer to go on to things which are more important.

Standardization of Materials

Standardization of materials is vitally important because material problems during the coming year will be serious ones. The question of steels, as well as of many other materials, will be a real problem, and the best way in which quantity delivery can be insured in this country is so to standardize the specifications that the steel mills can be given quantity orders in stock steels which they know will be called for, and not be subject to the whims of the individual designer who thinks he needs a few more points of carbon in his material. Nine times out of ten, differences in specifications are purely the peculiarities of the individual engineer, and do not in any way represent advances in practice, or even the best practice.

I will touch for just a moment on certain phases of the work of the National Defense. We have been in session here almost four hours. In that time four thousand tons of American and Allied shipping have been sunk. It is going down at the rate of one thousand tons per hour. We are not building at half that rate even. As a result, it should be evident to all of us that if we play too much of a waiting game there may not be any too much shipping to maintain an army in France after we get it there.

Therefore, it is vitally necessary to move rapidly. In spite of all the criticism which is indulged in by the papers because of seeming inactivity in Washington, under the surface there is a great deal of activity. Many things are going forward, and at tremendous speed, about which nothing is said. I do not believe that for a country which "sat tight" until three or four months ago—until the declaration of war—the progress we have made has been anything of which to be ashamed.

This is so true, in fact, that we are today sending Italy, France, England, and Canada. men by some hundreds, or even thousands, to enter the flying schools in those countries, which they can no longer fill with a suitable personnel of their own. These men will be trained in our uniform, under our officers, and will be returned to us in France after the training has been finished.

We are laying down twenty-four big training schools in this country. Those who have visited all the flying fields in Europe say that any of these fields, such, for instance, as the one at Rantoul, Ill., or the one near Dayton, Ohio, is a greater school for flying instruction than any single camp in Canada or on the other side of the water.

Air the Only Free Element

The sea is mined and netted, and full of submarines, so that progress in the water will not be very speedy while progress on land, as we have seen, is very slow. There remains only one element in which we are fighting now which is more or less free—the air. There are a thousand routes into Germany by air. The reason they are not used is because of lack of aircraft in the Allied lines.

At the moment the situation in Europe with regard to aircraft is pretty nearly balanced, and it is not likely that the situation on July 1, 1918, will be greatly changed. Both the belligerents are speeding up production of aircraft. During the first year and a half of the war the type of men who make the best fliers in the world, the young and adventurous spirits, were the first enlisted in the war and the first sent to the front. As a result, such men have largely been wiped out of these countries. We find ourselves today, in this country, the last great reservoir, not only of the materials for the manufacture of aircraft but of the human material that makes up the personnel of the flying corps.

Take, for a moment, the situation on the West Front, where on a 250-mile line there are massed, either on the line or immediately behind it, between seven and eight million men.

At various times we have seen the German generals move half a million men from the East to the West Front and throw them against this line without any perceptible denting of it, so that we can readily see that any troops sent to France cannot be expected to march in a triumphal procession to Berlin, as some of our Fourth-of-July speakers are so apt to indicate.

There are in foreign countries today, in active operation, heavier-than-air machines for use on both water and land, machines of as high as 900 hp., and in experimental stages there are machines of as high as 2100 hp.; these machines have three 700-hp. engines. Italy, particularly, has gone ahead in the development of aircraft of certain types. Her problems are problems of the mountains. She must have machines capable of traveling long distances, and of rising over the lower peaks of the Alps before they can get into Austrian territory.

She has developed triplanes with over a 100-ft. wing spread and three 300-hp. engines, and, as I say, is experimenting with machines of 2100 hp. She also is building, in an experimental way, machines of 3400 hp., capable of lifting about ten-tons' useful load in explosives, or any other materials, and transporting it.

Moreover, Italy has developed the fastest machines in the world, having officially timed them at 140 m.p.h. So all of the progress is not being made in France and England.

The Council of National Defense, in the first place, was formed as a peace-time organization. It was created before we had declared war, and was organized as an advisory branch of the Government, directly responsible to the President. The Council itself consisted of six cabinet officers, and with it was associated an advisory committee of seven business men.

This organization was supposed to collect information that sooner or later might be of advantage to the military departments, but upon the declaration of war it was suddenly called upon to take the reins in its own hands and to do many things necessary in order to avoid confusion. There is no question that the existence of this Council and the ability of its Advisory Commission to call into service in Washington the leading business men of the entire country has bridged this whole period between the declaration of the war and the present. This would have been a period of almost utter chaos had the regular military machinery, as it existed in Washington at the outbreak of the war, been called upon to carry the tremendously increased load. What the air service alone has been called upon to do is a marker for practically all of the other activities.

During the eight years previous to 1916 the United States Government ordered fifty-nine airplanes from four different manufacturers. On Aug. 29 last an appropriation was made of about thirteen million dollars for the War and about five, as I remember, for the Navy Department. Then, before the departments could adjust themselves to this expansion from eight hundred thousand, or say a million, over eight years, to nineteen million in one year, they were suddenly confronted with the necessity for organizing in the War Department alone upon a yearly basis of six hundred and forty millions, and in the Navy Department upon a basis of forty-five millions. In short, all told for this year, nearly eight hundred millions of dollars must go into the development of the air service.

With an expansion of sixty times the volume of business they have ever done before, the military departments, as constituted under the peace-time military regime, would have been swamped had it not been for the possibility of drawing in the best business talent of the country, giving them commissions under the Officers' Reserve Act and putting them to work in the departments to help carry this load.

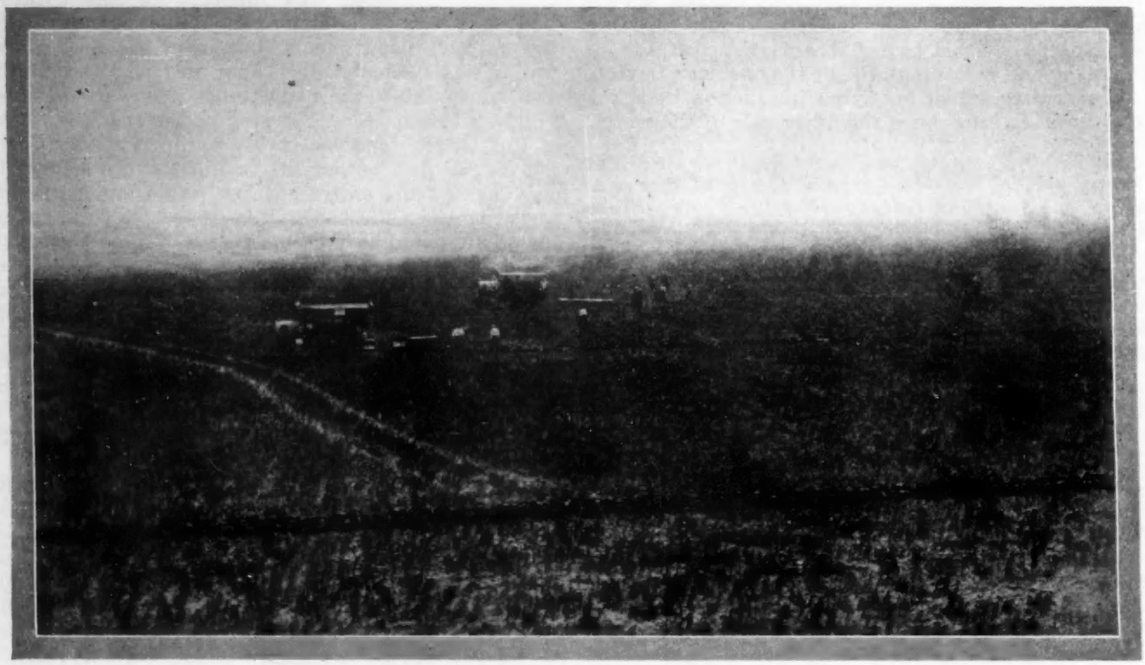
Civilians in Business of War

That is exactly what is happening. Civilians who have never carried a gun in their lives, who have never had a day's military training, are going into the departments with the grades of captain and major, and shouldering the load of the business of war, which, after all, has become even more vital in some ways—at least in this stage of the preparation—than is the actual military training itself.

I sometimes say that in war now, as in ordinary things of life, there are three "graces"—Army, Navy, and Industry—and the greatest of these is Industry, because it is far the most intricate, and needs by far the greatest coordination.

In the industrial end we are not treading any beaten path laid down by military tactics. It is a brand new thing that will tax the ingenuity of the best business managers and business men in this country.

In all of this work there is no more important link in the chain than the automotive activities, and I hardly need to say to S. A. E. members that the organization of which they are a part has done more within the last year, or the last two years, toward the accomplishment of the purposes of the national defense than all of the other engineering organizations in the United States. And that is not an idle compliment. Those of us who are in the thick of the game in Washington appreciate the way in which S. A. E. members are attacking all of the problems entering into the automotive activities.



Machines in Operation at National Tractor Demonstration

The Tractor from the Viewpoint of Farm Management

By ARNOLD P. YERKES* (*Non-Member*) *Illustrated with* CHART AND PHOTOGRAPH

THERE are two distinct angles from which the tractor is usually considered, one the manufacturer's, the other the farmer's viewpoint. The problems of the manufacturer are largely those which must be dealt with by the engineer and sales manager, while those of the farmer are for the most part problems in farm management, dealing with the practical application of the tractor to farm operations, and its economic value. In other words, farm management's and the farmer's viewpoint are the same. There are many farm-management problems involved in the utilization of the tractor which should be of interest to the tractor engineer and designer, as they have an important bearing upon the trend of the industry.

A subject which is of the utmost importance from a farm-management standpoint, and which should be of interest to the engineer is that relating to the size of farm on which tractors can be used profitably. Many people appear to be under the impression that the farms in this country are growing smaller each year, and that the demand for small tractors should therefore increase. The foundation for this belief, in many cases, is the figures given in the U. S. census showing the total number of farms in the country at different dates. "Figures don't lie," but they are easily misinterpreted. In this case they have not been carefully analyzed. While the figures showing the total number of farms do indicate a heavy increase in the number of farms of less than 100 acres, many of these are small truck farms of less than twenty acres, and need not be considered as a tractor market. Most of the others are in sections where tractor sales, for several years, at least, will be negligible. In the States which are ordinarily considered as the principal tractor market both the number and percentage of farms of from 50 to 99 acres decreased considerably from 1900 to 1910, while the number and percentage of farms ranging from 100 acres up increased.

The introduction of labor-saving farm machines has a tendency, other things remaining equal, to increase the size of our farms. This has always been true in the past and will undoubtedly be true in the future. Our investigations show that the tractor is having a decided influence in this direction. A large percentage of farm-

*Assistant Agriculturist, U. S. Department of Agriculture.

ers, after purchasing a tractor, increase the size of their farms to a very considerable extent.

Farm-management studies have shown clearly that there is a sound economic reason for the decrease in both number and percentage of farms between 20 and 99 acres in the Middle Western States, while the number and percentage of farms both larger and smaller increased. The reason is that farms from 20 to 99 acres in this section are of inefficient size; they are too small to make efficient units for the type of farming commonly followed in that section, hence some have been combined to make farms of a profitable size, while others near cities or convenient to transportation have been divided into truck farms.

SIZE OF FARMS IN ILLINOIS, IOWA, MISSOURI, KANSAS, NEBRASKA, NORTH AND SOUTH DAKOTA.

Size of Farm	Percentage of Total Number of Farms 1910	Percentage of Total Farm Acreage 1910
Under 20 acres	5.6	0.3
20 to 49 acres	9 4	1.6
50 to 99 acres	17.7	6.8
100 to 174 acres	32.6	23.6
175 to 499 acres	29.2	42 0
500 to 999 acres	4.4	15.2
1000 acres and over	1.1	10.5
	100.0	100.0

Most tractor engineers desire to design a machine to meet the greatest demand. From the accompanying figures he can judge for himself which sizes of farms will probably be the heaviest users of tractors. (It must be remembered that the total acreage of any group of farms of a similar type is apt to be a better guide of their buying capacity than their number.)

From these figures it will be seen that while farms of less than 100 acres represent approximately one-third of the total number of farms in these States, they contain only 8.7 per cent of the total farm acreage. Their tractor capacity will probably correspond very closely with the latter figure. Farms of from 100 to 499 acres represent 65.6 per cent of the total farm acreage, and it seems reasonable to believe that in this group will be the bulk of tractor sales. The farms of 500 acres and over, while only 5.5 per cent of the total number of farms, contain 25.7 per cent of the farm land, and each of these farms should represent a potential tractor market.

EFFICIENT SIZES OF TRACTORS

Closely related to the size of farm is the size of tractor best suited for general use. The Office of Farm Management has given careful consideration to this point and has made inquiry of thousands of experienced owners. The results of such studies were published a little over a year ago, and I may state that the thousands of detailed reports received from users since that time corroborate the facts as published. Judging by the experience of these men the three and four-plow outfits are the most efficient sizes, all things considered. A very large percentage of men who have used two-plow machines state they are too small, and recommend those capable of handling three or four plows. Of the large number of men who are using three-plow outfits none advised anything smaller although several recommend the four-plow rigs. At the same time a considerable percentage of men who have used six, eight, and ten-plow tractors, principally owners of exceptionally large farms, state that the medium sized outfits would be more economical. There are, of course, a number of factors which influence the size of tractor best suited to the individual farm, but the indications are that a four-plow machine will most nearly meet the requirements on the greatest number of farms on which tractors will be used.

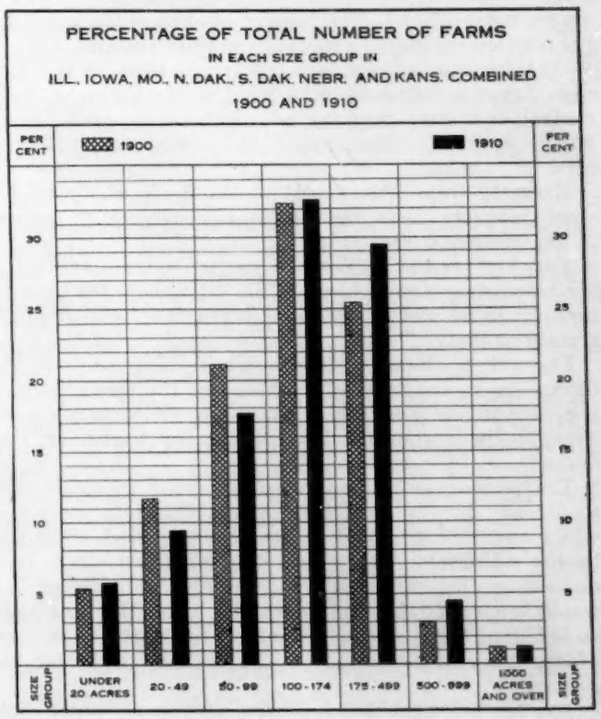
FARM POWER POSSIBILITIES

Belt work is the largest item which can be included under one head; this represents, on an average, about 50 per cent of the work which the tractor generally does on farms. This, of course, includes many different kinds of work, but usually there are only two limiting factors involved; one is the amount of power available for the heavier operations such as cutting ensilage or running a separator; the other is the question of economy in doing the lighter jobs. Aside from these the nature of the belt work is immaterial; the tractor will take care of it.

Plowing, of course, is essential, also work in preparing the land for seeding, such as disking, harrowing, packing and pulverizing. These are too familiar to warrant discussion.

The problem of cultivating is apparently in a fair way to be solved by the production of low-priced gasoline-driven cultivators, which are also capable of taking care of light two-horse operations, such as operating a corn-planter and a grain-drill. Aside from the quality of the work and ease of manipulation these do away with the necessity for moving a heavy plowing tractor over soft ground in order to perform light work, and would thus seem to justify their purchase on farms where any considerable amount of cultivating was required. They should also help out with the lighter belt work.

Mowing with the common type of horse mower, while possible, is rather an awkward and unsatisfactory operation, and usually increases rather than decreases the man labor required per acre. The same is true with binding. However, a heading device is on the market



which is mounted on the tractor's own frame, permitting absolute freedom in operation, and control by one man. It is certainly not expecting too much to look for a similar solution of the binding and mowing operations, and if a grain binder, then why not a corn binder? Nor does there seem to be reason for doubting that both side-delivery and sweep rakes could be attached in somewhat the same manner, thus making the tractor a valuable addition to the farm equipment in haying season, when it must now stand idle or be utilized very inefficiently.

For hauling, the tractor, unless it is a very small one, is practicable only for heavy loads. This means either special wagons or a wagon train. The latter is unsatisfactory under most conditions because of its unwieldiness and troubles caused by inability to back. In many places unloading facilities prevent the use of the wagon train. The truck or automobile trailer will probably be more useful and practicable in most cases, while in others the tractor will be satisfactory for this work.

For hauling manure only small outfits are practicable; the larger machines are not loaded economically. There would seem to be no reason, however, why special manure spreaders of large capacity should not be made for use with tractors.

Horse Equipment Undesirable

This completes the list of the principal farm operations which the tractor reasonably should be expected to perform. In utilizing it as an all around source of farm power the important consideration would seem to be to give it a fair chance by furnishing equipment designed for use with a tractor and not attempt to compel it to operate with equipment designed for use with horses. The two sources of power are entirely dissimilar. Most farm machines are operated with a rotary motion of some parts. When horses are employed this rotary motion must be obtained by means of gears driven by friction wheels in contact with the ground. The horse is also capable of moving sidewise as well as forward or backward, hence it is no handicap to operate a machine drawn behind him. The tractor, on the other hand, can furnish power with a rotary motion without the aid of the friction wheels, and while it cannot move sidewise it moves backward or forward easily, giving splendid control over any machine mounted on its own frame, but is distinctly handicapped by a machine drawn behind it.

Extracts from letters sent to the S. A. E. by tractor manufacturers have mentioned the subject of service in the following terms:

The first reads: "We are particularly interested in the tractor service problem. This represents the greatest problem to be met in the more rapid development of the tractor industry."

The other states: "The most serious subjects for discussion in the tractor business are the service end of the proposition and the relationship which service will bear to the standardization of tractor parts, or vice-versa."

The problem of standardization must be dealt with principally by the engineer. While this is a matter in which the farmer should be greatly interested, since it is to his advantage as well as the manufacturer's, it is one concerning which he is generally uninformed. It would seem that the desired results along this line must be achieved through cooperation on the part of the manufacturers and education of the farmer regarding the subject.

The service problem, however, is one in which both manufacturer and farmer are vitally interested, and is of sufficient importance to deserve the entire space of this discussion. The business of both the manufacturer and farmer is suffering because of it, and must continue to suffer if it is not solved. The quotations given indicate that the manufacturers realize the importance of the subject, and the following extract from a letter received last week by the Office of Farm Management shows that the farmer also realizes its importance. It likewise indicates very clearly how both the manufacturer and farmer suffer because of this trouble. I may say that the letter was picked at random to illustrate this point; we receive many similar ones daily. The letter, with some grammatical changes, reads as follows:

"This machine was the cause of my losing my entire crop the year I bought it, as I didn't have any other power to put it in at the proper time. When I bought this machine I had to pay every cent on it before I got to see the machine. After the company got my money they told me to communicate with their agents in St. Louis thereafter when I was in trouble. I wrote to these people; they told me I was not entitled to any information as I had not bought the machine from them. The company had my money and I had their scrap. The company has offered to take this old machine as part payment on the new one, provided I pay for the new one at the factory, which I shall never do. If I ever buy another machine it will be right here on the farm doing the work. I don't know any one in this neighborhood who has a machine for farm purposes, as every one was watching me and I had too much trouble to encourage anybody."

Of course, this is only one side of the story in a particular case, but it serves to illustrate the point. Many farmers complain of delays at critical times in the working season in obtaining repair parts. One writes:

"I lost more time waiting for repairs this spring than it took to plow sixty acres. Then come those high-priced repair, telephone and express bills."

Many others give as a reason for selecting some particular make of tractor the fact that the factory was located nearby, or that repair parts could be obtained readily at some local agency. I mention this merely to show that in many cases the question of service is considered by the farmer before the purchase is made and is, therefore, a strong factor in determining the particular make of outfit which he will buy.

Solving the Service Problem

So much for a brief statement of the problem as it exists. The statement of the solution is not such an easy matter. While I had no trouble whatever in finding plenty of letters to illustrate the lack of satisfactory service I had difficulty in finding any mentioning its existence, which goes to show how ready the average man is to complain, and how backward with his commendation. Finally, however, I found the following:

"I cannot report that my experience has been satisfactory, for the reason that there have been too many annoyances and delays in the operation of the tractor on account of defects appearing which brought about many delays and very much expense.

"My understanding with the company when I purchased the tractor was that they would furnish a man to rectify any trouble that would appear in the operation of the tractor. The consequence was that for six months I had them sending a man to look after the tractor two or three times a month. Finally after plowing about 200 acres they furnished complete repairs for

everything that required replacing. In order to give you an idea as to what this amounted to: They gave me a credit memo for the items, aggregating over $400. Considering that I originally paid $1,000 for the tractor, this explanation will indicate to you the continued annoyance and trouble I had with the operation of this tractor. The company, of course, took the position that the man operating the tractor was not conversant with its operation—consequently, it resulted in wearing out parts that could have been avoided if he had been more familiar with his duties. However, right here, wish to state that the man I employed was very much above the average man that a farmer can obtain to operate a tractor.

* * * * * *

"Wish it distinctly understood that the company treated me fine, and gave assistance in every way to take care of every trouble that appeared, and finally replaced all the worn-out parts with new repairs without charge."

This shows the nature of the service some companies are furnishing; certainly they did all or more than any one has a right to expect, but it is not really satisfactory to either themselves or the farmer, as it represents heavy expense to both.

So far as the farmer is concerned the only "service" he really cares about is that received from the machine itself, in other words, anything less than perfect performance on the part of the outfit is bound to be unsatisfactory to him. In the absence of this he is, of course, interested in having first-class "service" from the manufacturer, in order to reduce delays to a minimum.

It is obvious that a really fool-proof and absolutely reliable tractor would solve the difficulty, but, unfortunately, the manufacturers and their engineers while working toward this end have not yet attained it.

Perfect "service" from an imperfect machine can scarcely be expected, but the nearest possible approach to it will be attained when the outfit is handled by a first-class operator. To state it another way, the more proficient the operator the better the performance of the machine and the less the service which is demanded of the manufacturer. Is it not logical then to believe that the solution of the problem must be brought about largely through the education of the farmer in the proper care and operation of the tractor?

Better Operators Required

The hiring of competent operators is frequently suggested, but most farmers feel that they cannot afford to pay the prices such operators rightfully expect. It would therefore be necessary to convince the farmers that it would pay them to hire such men, so why not convince them that the proper thing to do is for either their sons or themselves to spend a little time and a few dollars in acquiring a training which will enable them to save many times its cost in both time and money by handling the tractor intelligently and economically, thus avoiding expensive delays.

The hired operator is an uncertain proposition for the farmer in any event, as it is extremely difficult to ascertain the qualifications of an applicant for the job. Many cases have occurred where men represented themselves as expert operators and demanded high wages, yet were utterly incompetent and incurred heavy repair bills by their inefficient operation of the outfit.

It would appear that some manufacturers have felt that it was a discredit to their tractor to admit that a man need spend any time in learning to operate and care for it. Extravagant claims that "anybody can run it" have resulted in many farmers feeling that it was an admission of a lack of even ordinary mechanical ability on their part to require instruction in the operation of a tractor or to ask for advice concerning it. This fact has been largely responsible for the need of so much service being required after machines have been in operation a short time.

Actual experience in thousands of cases has shown so conclusively that running a tractor is not a job for either a boy or inexperienced man that it should be unnecessary at this stage of tractor development to have to take time to contradict the old statement that "any boy can run it." Every experienced tractor manufacturer knows better, and the new ones who still make such claims not only show their lack of experience but are paving the way for service troubles at a later date by misleading the purchaser and preventing him from taking the trouble to inform himself fully regarding the operation of the outfit.

The tractor is strictly a business proposition with the farmer. He cannot afford to risk delays with his work at critical seasons when a small amount of time and money spent in learning how to run the outfit will give a strong guarantee that such delays will be avoided.

From both the farmer's and manufacturer's viewpoint, therefore, the best way of solving the service problem would seem to be through its elimination by putting the farmers in a position to get a higher degree of service from the machines and requiring less from the manufacturer and his agents.

The Discussion

Mr. Moyer: How many tractors were in operation last year?

Arnold P. Yerkes: We requested thirty-two thousand crop reporters to furnish us with the names and addresses of all the men they knew in their territory who used tractors. In the States west of the Mississippi River we sent to the county crop reporters, as well as the township crop reporters. We got back about 34,373 names, some of which were undoubtedly duplicates. In some States in the West, where a crop reporter is not in close touch with all the men in his territory, the names of some users may have been omitted.

Our figures for east of the Mississippi River, I feel, are about right.

Just how far off we are west of the Mississippi it is hard to tell. The census taken in Kansas showed thirty-nine hundred tractors in operation. Our figures showed about twenty-two hundred. I have been told, though, that Kansas included steam tractors. In that case, maybe we are not so far off after all. Our figures check pretty closely with those obtained by county agents, who know every tractor in their counties.

We have sent a letter to all of the 34,373 owners and asked them to give us the names of all the users they know. Practically three-fourths of the men in the office of Farm Management are working on the labor situation, so that we have had to drop nearly all of our farm management studies. I hope we will be able to give more definite figures next year.

Mr. Buskirk: Has Mr. Yerkes any information as to the average size of farms using those tractors?

Arnold P. Yerkes: The size varies, of course, in every State. In Kansas the average farm is much larger than in Indiana. All that information is at Washington, and we will be only too glad to give it to any one. Our

bulletins are put out primarily for farmers, so naturally we cannot include such data, because the farmer is not interested in them.

There is one thing I did not say about that tractor census. Many of the old tractors that were sold five, six, and more years ago have gone out of use or may have been excluded. We asked for the number of tractors actually in use on farms during the current year. That eliminated hundreds of the large tractors used in the Northwest. It also cut down tremendously the number in North and South Dakota, in Montana, and probably in Kansas there were also many tractors not in really active farm use. We did not include any road-work tractors, of which many hundred are in use.

E. W. McCULLOUGH: Is the horse-drawn farm equipment keeping back the sale of the tractors from an economic standpoint?

ARNOLD P. YERKES: The farmers are hitching tractors to the machines made for horses. The fact that the machines are made for horses is not holding them back, but is, I think, resulting in many impracticable hitches. The linear motion is converted into a rotary motion for the horse-drawn mower, and then when a tractor is attached the rotary motion is converted into linear, and back again into rotary through the friction of the ground.

I feel that the power should come direct from the engine, thus eliminating the hitch to the tractor. The minute two power wheels are used we cannot back satisfactorily, and we have an unwieldy outfit. It seems the tractor needs machines made for it.

PRESIDENT GEORGE W. DUNHAM: If a farmer has a number of tools on hand, those are undoubtedly applied to tractors in a more or less inefficient way. If we educated a man thoroughly when selling him a tractor we could control those conditions and show him, if he had to apply those old tools, the best way to do it and insure good care of the machine.

H. C. BUFFINGTON: What size of tractor is used for belt work?

ARNOLD P. YERKES: Two-plow tractors usually do not have enough power for the silage cutting, or even for the small thresher. That has been the experience of those with whom I have talked and corresponded.

There is a tendency on the part of the farm hands, when running a silage cutter, to choke the thing down if it can be done. They do not do as much work then, for they spend ten or fifteen minutes cleaning it out. It is the same way with a separator. The farmer always wants an engine that will keep his machine going. That is one objection the small-farm owners have to the small size of tractor. Two plows will plow all the land on a good many farms, but the belt work is just about fifty per cent of its work. That is a limiting factor on many farms, not the plowing at all.

Burning Kerosene in Tractor Engines

By W. G. CLARK* (*Non-Member*) *Illustrated with* PHOTOGRAPH AND CHARTS

THE use of low-grade fuels for tractor and truck engines has been for some time the subject of considerable debate and experiment. Of the data now available on the subject there are many that are conflicting and erroneous, but enough careful work has been done so that certain fundamental principles, essential to efficient and satisfactory use of low-grade fuels, have been established and are more or less common knowledge. These requirements are well defined and have been put before engineers and manufacturers many times. The shortsightedness of the majority of engine manufacturers, and their reluctance to effect changes in design which are so necessary in handling low-grade fuels, have been chiefly responsible for the failure of most of the so-called kerosene tractors, and have given kerosene and other low-grade fuels their present ill reputation.

The object of this paper is to again set before those most interested what has been done and what must be done to make all our tractors successful in operating on low-grade fuels, and in this way to further the work of cooperation and standardization so vitally necessary in the tractor industry today.

*Chief Engineer, Wilcox-Bennett Carbureter Company.

The treatment of all low-grade fuels is essentially the same, but I wish to deal more specifically with kerosene, as it seems to offer the most logical solution of the present fuel problem.

All experiments with kerosene show conclusively that heat must be applied to assist in vaporizing the fuel, particularly for multiple-cylinder engines, so that the first step in the solution of the problem lies in the determination of the best method of applying the heat. There are four principal methods now in common use:

(1) Applying heat directly to the liquid fuel before it leaves the nozzles. This gives maximum power and fair economy, within limits, but lacks flexibility.

(2) Exhaust-jacketing of the intake manifold, which heats the whole mixture. This entails a high volumetric loss, but gives good economy and flexibility.

(3) Preheating the air before it enters the carbureter, which produces a high volumetric loss and poor economy. This method does not apply the heat at the right time or in sufficient quantity, with the result that a large part of the fuel either goes out with the exhaust or into the crankcase.

(4) A compromise of the two extremes, effected by

exhaust-jacketing a part of the carbureter above the bowl. The fuel charge and a small portion of the air are heated to a high temperature, and after passing through the heat chamber are diluted and mixed with cold auxiliary air. This produces a mixture with all the advantages, to a slightly modified degree, of the other methods, and with none of the disadvantages.

There are numerous combinations and modifications of the above methods of applying heat, but they all can be classified under one of the four heads.

With the hope that perhaps it will save others unnecessary work, I will outline a few of our experiments in determining the best method of obtaining proper low-grade fuel mixtures.

Our first attempts to burn kerosene were made in 1911, on a 6½ by 8-in. four-cylinder L-head engine. We first used an exhaust-heated box (Fig. 1) containing a coil of pipe. This pipe was connected to a carbureter and to the engine manifold. The kerosene was drawn through the pipe coil with a small quantity of air and heated to a high temperature by the surrounding ex-

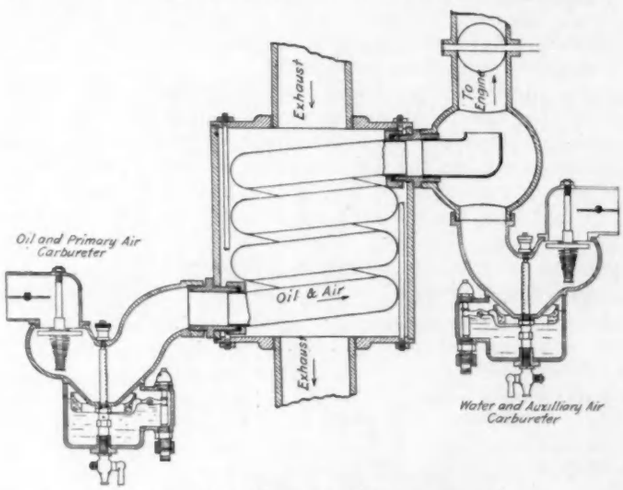


FIG. 1—EARLY TYPE OF OIL CARBURETER

haust. After passing into the manifold the hot, rich mixture was diluted and cooled with cold air and water vapor, drawn from a second carbureter connected to the manifold beyond the heater. With this apparatus we lost too much power and had great trouble with preignition and formation of carbon in the heater.

We then tried forcing the mixture through with a portion of the exhaust to reduce resistance in the heater and to increase the temperature, but we still lost power, and the preignition was worse than ever. The pistons were then given more clearance, and a stream of cold water turned onto the spark-plugs, which were in the valve caps, and the preignition was materially reduced. Although the temperature got as high as 900 deg. fahr., the fuel did not crack. We proved this by interposing a radiator as a condenser between the heater and the manifold, and were then able to condense the fuel back to raw kerosene. This apparatus was described in a paper* presented by A. C. Bennett in March, 1913, before the Metropolitan Section of the Society.

The second apparatus was a slight modification of the first, and was used on the silver-medal winner of the 1911 Winnipeg Tractor Contest. It gave good economy and flexibility, but lacked power, and was extremely cumbersome. Fig. 2.

*S. A. E. TRANSACTIONS, 1913, Part I, p. 211.

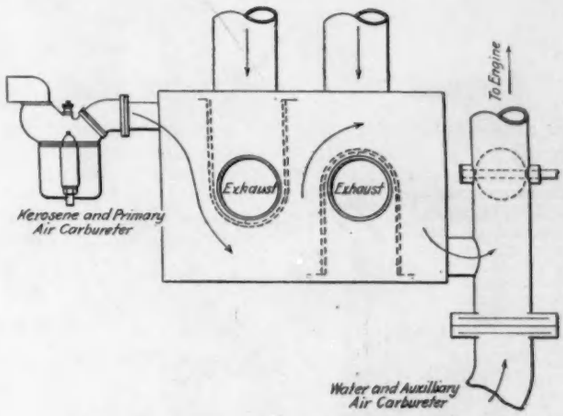


FIG. 2—APPARATUS FOR BURNING KEROSENE

Fuel-injection methods were next tried, but were found to be too delicate on account of the small quantities of fuel used. Mechanical difficulties also involved so many complications that this method was abandoned as impracticable.

We also tried heating the air in an ordinary gasoline carbureter, but again lost too much power, and encountered more preignition and distribution trouble.

The next logical step was to heat the fuel, which we accomplished by exhaust-jacketing the fuel bowl. Figs. 3 and 4. By deflecting a portion of the exhaust gases through this double bowl we could maintain the temperature of the liquid fuel nearly at the boiling point. To atomize the fuel, we used a multiple-jet standpipe with about seventy-five jets. This broke up the liquid into very fine particles, giving a decided gain in horsepower, although the economy was practically the same as with the first heater at full load. The light-load economy and the flexibility were not so good.

We next worked to get better economy and flexibility by making various devices to break the fuel into finer particles (Fig. 5). Some successful ones were tried, and improved the economy greatly at full load, but they proved to us that light-load economy and flexibility are dependent on high temperatures unless excessive gas velocities are maintained. But to maintain a high gas velocity at low speed means wire drawing and volumetric

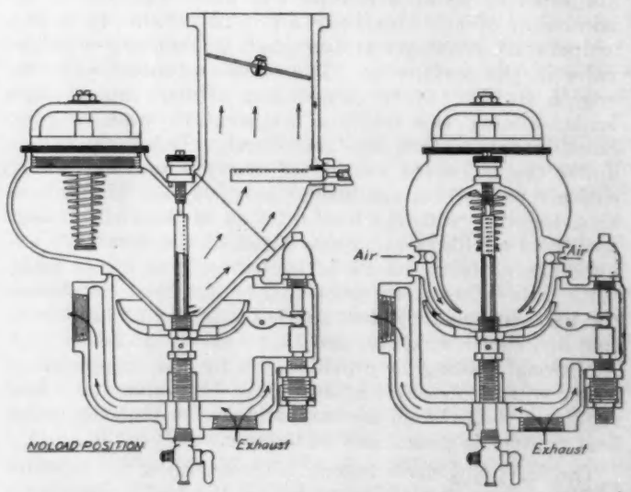


FIG. 3—EXHAUST-JACKETED KEROSENE CARBURETER AT NO-LOAD POSITION

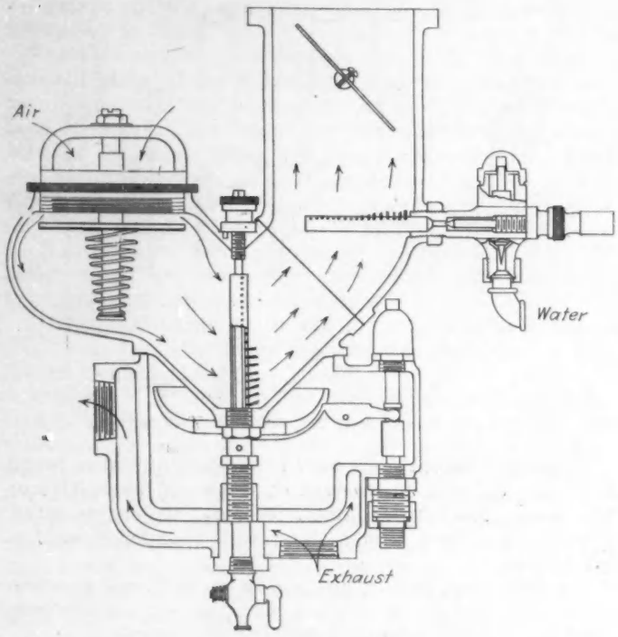


FIG. 4—KEROSENE CARBURETER AT HALF-LOAD POSITION

loss at high speed, so we abandoned our mechanical vaporizers and went back to the heat problem.

These experiments had shown that we must use high temperatures for light loads and low speeds, and as little heat as possible at heavy loads and high speeds, depending on velocity to prevent condensation at the higher speeds.

After numerous experiments with jacketed manifolds and various combinations of heated air and heated fuel, we evolved our present type of carbureter, which is a compromise, embodying as far as possible the best features of our other designs so as to give the maximum of power consistent with flexibility and economy. In this carbureter (Fig. 6, 6a, 6b) we utilize the whole exhaust, passing it around a heat chamber through which the fuel and a small portion of air are carried. The high temperature to which this primary mixture is subjected is lowered beyond the heat chamber by the admission of cold auxiliary air. To obtain the higher temperature necessary at light loads we employ a weighted valve in the carbureter. The valve is controlled by the engine suction, which admits hot primary air at light loads, raising the mixture temperature when the exhaust gases contain the least heat. This valve closes under the increased suction of heavy loads and admits cold air to the heat chamber with the fuel. This admission, together with the final dilution of the rich mixture with cold auxiliary air, helps to offset the increased and unnecessary temperature of the exhaust at heavy loads. With this scheme we obtain the best heat conditions for kerosene, namely, hot air, hot mixture at light load, cold air, cooler mixture, and high velocity at heavy load. Additional cooling is provided for by the admission of water when necessary, by means of the same valve that regulates the primary air temperature, so that the entire heat control is practically automatic.

The foregoing deals merely with obtaining the mixture by the proper application of heat. We had innumerable difficulties with gas distribution, manifold condensation, pistons and spark-plugs, which I wish particularly to consider in order to show that the kerosene carbureter does not exist as such by itself. The kerosene tractor, however, must include:

(1) An efficient vaporizing device to produce a homogeneous combustible mixture.

(2) A properly designed manifold to carry the mixture to the cylinders without condensation and with uniform distribution.

(3) An engine so designed as to take care of the higher operating temperatures of kerosene and capable of burning a kerosene charge efficiently.

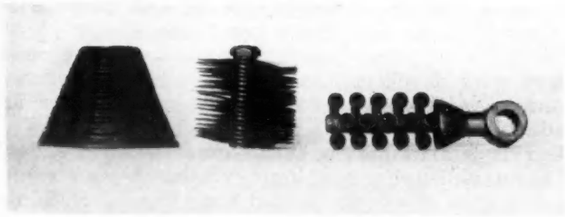


FIG. 5—DEVICE FOR BREAKING UP FUEL PARTICLES

The first two requisites have been more fully developed than the third, and until the engine manufacturers and the accessory men cooperate in producing a real kerosene engine the kerosene tractor will remain as it is now, a makeshift at the best. There is no gainsaying the fact that the majority of so-called kerosene tractors are failures. The best of them are far from being as efficient and easy to operate as they should be.

Gasoline equipment will not handle kerosene satisfac-

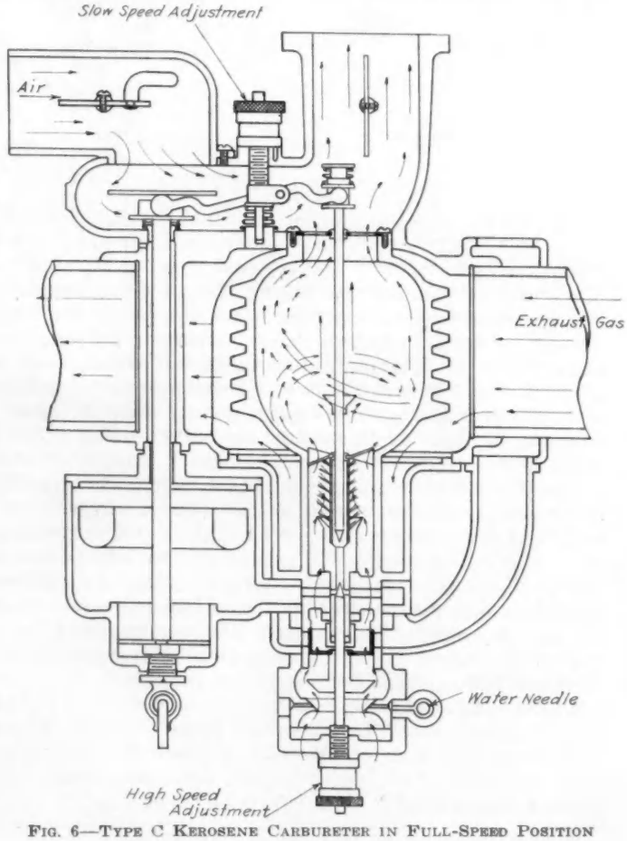


FIG. 6—TYPE C KEROSENE CARBURETER IN FULL-SPEED POSITION

torily, nor will the installation of a kerosene device make a kerosene engine out of a gasoline engine, notwithstanding popular belief to the contrary.

The failure of the engine makers and the carbureter men in the past to get together and secure the best results in handling low-grade fuels is due to several things, chiefly:

(1) The reluctance of most of the engine manufacturers to accept the results of outside experiments as affecting engine design.

(2) The high cost, lack of adequate facilities, and time required for effective experimental work.

(3) Stress of increased production demands, precluding radical changes.

The result has been that the carbureter men have assumed the whole burden, and have been expected to produce an instrument that will make a kerosene-burning engine out of the existing types of gasoline engines.

Kerosene Engine Design

All of the kerosene-burning tractors now on the market can be roughly divided into two classes: those in which efforts have been made to adapt the engines for kerosene work, and those that simply have one of the numerous kerosene devices attached. The latter are by far in the majority, and it is largely owing to their failure as efficient kerosene tractors that the poor opinion of kerosene as a fuel exists. To illustrate how machines in this class will fail, take the experience of a service man who was delivering a new tractor. It was one of those equipped with a heated air carbureter for kerosene, and as is usually the case when these machines are running with light load the mixture had to be pretty rich in order to keep the engine going. After traveling a few miles from town the lubricating oil got so diluted by raw kerosene working past the pistons, that two bearings burned out before the operator was aware of it. This was on a new machine that had not even reached its point of delivery.

The first and most important things to consider in kerosene-engine design are the clearance and cooling of the pistons. Owing to the higher operating temperatures in kerosene work, the heating and expansion of the pistons are much greater than with gasoline, so that the clearance between the cylinder walls and the pistons must be greater to prevent seizing and scoring. Experiments with various types and sizes of pistons have shown that the body clearance should range from one to one and a half thousandths per inch of diameter. The rest of the piston should be tapered toward the head with a clearance of four or five thousandths per inch of diameter at the extreme top. Fig. 7. This is considerably more than the clearance used in automobile practice, but the tractor piston is subjected to higher and more sustained temperatures than the automobile piston ever is. If clearances are not sufficient to take care of the additional expansion the pistons will seize and score the cylinder, or at least cause heavy preignition.

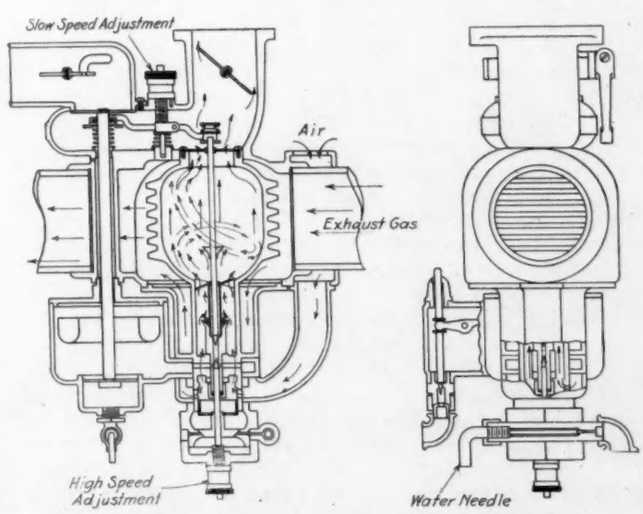


Fig. 6A—Type C Kerosene Carbureter in Slow-Speed Position

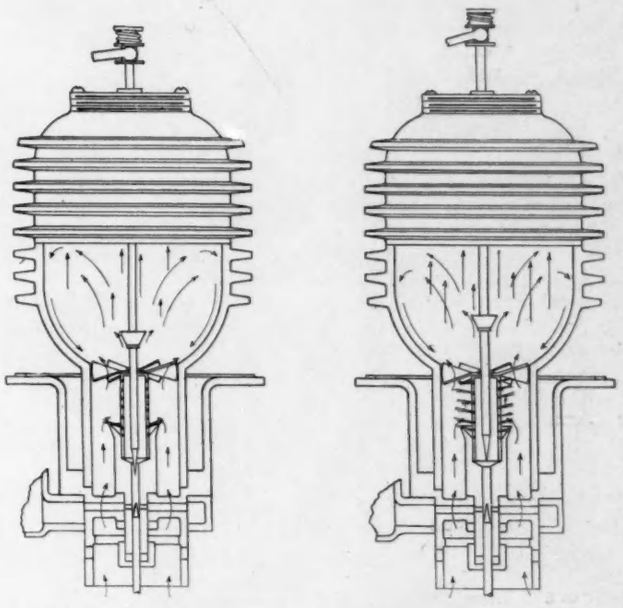


Fig. 6B—Type C Carbureter in No-Load (Left) and Full-Load (Right) Positions

Piston heads should be thick and well ribbed and filleted to carry the heat away from the center of the head to the piston body, when it can be transmitted to the water-jacketed cylinder walls. If this is not done, the center of a piston will frequently get red hot and cause preignition.

Ring gaps should also be slightly greater in the kerosene engine to allow for expansion. Water jackets must be extra large and unobstructed, and should be carried a trifle lower than is customary in gasoline designs so as to afford a free and uniform circulation of the cooling water and to help carry heat away from the body of the piston.

Valve seats, especially exhaust-valve seats, should be well water-jacketed, because a hot valve or valve cap will cause a great deal of preignition trouble that is hard to locate. Fig. 8.

The form of the combustion chamber, the efficient cooling of the valves, together with the fact that the intake passages have so few turns and pockets make the valve-in-head engine so well adapted to low-grade fuels.

The compression is usually somewhat lower in kerosene work, although it is difficult to give any fixed rule for determining it. We have found that the best results are obtained by lowering the compression as far as possible without sacrificing power. In some engines it is possible to drop the compression twenty or thirty pounds without losing in maximum power, although naturally the fuel economy and efficiency will not be so good. For

good all-around work the compression rarely exceeds sixty-five pounds, although it can sometimes be carried higher in an exceptionally well-cooled engine.

The type and location of spark-plugs is a very important factor in kerosene work, because the spark-plug is one of the commonest sources of preignition. A plug with a heavy metal body and heavy wire electrodes presents a large heating surface to the burning charge and often becomes red hot, causing excessive preignition.

The plug should preferably be located in the center of the cylinder head in a well water-jacketed position, so as to be cooled as much as possible. A spark-plug placed in a valve cap, especially over a hot exhaust valve, cannot be cooled, and will burn up and cause preignition with kerosene fuel. Fig. 9.

Cylinder combustion-chambers must be smooth, since rough spots or small metal projections soon become glowing points.

Distribution of the Fuel

There is still much to be done toward perfecting the design of manifolds for low-grade fuels. In multiple-cylinder engines the problem of distribution without condensation of the fuel is just as important as and probably more difficult than the production of a vaporized charge. Experiments have shown that kerosene mixtures will condense in the manifold at temperature below 350 deg. fahr., unless the gas velocity is kept high. For this reason the best results are obtained by making the manifolds as small as possible without causing a power loss and wire drawing. This is feasible with the tractor engine because it is still essentially a slow-speed unit.

We experimented with a manifold composed of a bundle of small copper tubes soldered together and having in it a sliding throttle, which controlled the number of tubes in operation. We were thus enabled to maintain a practically constant velocity at all speeds, which meant that by carrying an initially high velocity we could maintain a dry mixture with the minimum of heat.

In some of our earlier kerosene experiments, excessive manifold condensation gave us a great deal of trouble. We found that by placing dams of baffles in the manifold that this trouble could be greatly reduced. The fuel in breaking over the sharp edge of the baffles was pulverized

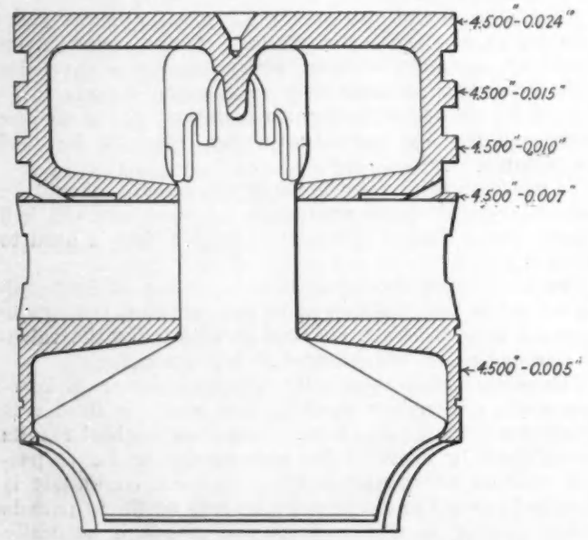


Fig. 7—Piston for Kerosene-Burning Engine

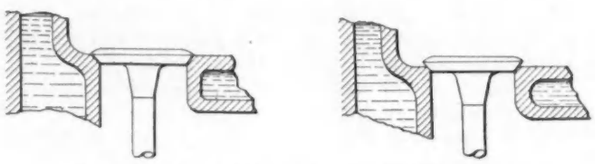


Fig. 8—Types of Exhaust-Valve Cooling Methods

into very fine particles instead of going through in large globules. Fig. 10.

I believe that a manifold should not pass through the water-jacket if kerosene is to be used as a fuel. The temperature of the water-jacket is lower than the mixture temperature at light loads, so that condensation and loading would result, although at full load it would not make so much difference.

In general a small manifold designed for uniform distribution and as short as possible will give the best results. It is hardly necessary to dwell on the fact that the fewer the turns in the manifolds and pockets in the valve chambers and cylinders, the better the distribution and operation obtained.

The present design of engines with opposed cylinders with their long exposed manifolds offers the greatest difficulties in distribution of heated mixtures. However, these difficulties can probably be largely overcome by exhaust-jacketing insulation or by retarding the intake-valve opening to obtain a high vacuum.

The designs of double or exhaust-heated manifolds now in use for multiple-cylinder engines are all more or less open to criticism. In most of them only the upper wall of the intake manifold is in contact with the exhaust. Fig. 11. This construction produces a condition in the mixture which is diametrically opposite to that desired. The lighter and therefore more thoroughly broken-up particles of fuel impinge directly on the upper hot surface, while the heavier unvaporized globules of fuel follow the lower and less-heated wall, especially at low velocities. This does not make for a homogeneous mixture, and is likely to produce carbon through cracking.

Another form of the exhaust-heated manifold which does not distribute the heat uniformly is of the type that allows the exhaust to escape from one end only. This means that those parts of the intake nearest the exit receive more heat than other parts farther away.

In spite of precautions against preignition we invariably encounter it in high-temperature work unless the compression is so low that the efficiency is greatly decreased. A well-designed engine will deliver a little more than three-quarters of its maximum power without preignition, so that it should not be necessary to use water in the mixture much below that point. The primary object in using water is to cool the mixture before it enters the cylinders, so as to keep the volumetric efficiency as high as possible and to prevent preignition. In some types of engines a large amount of water is necessary, varying from 20 to 50 per cent by weight, but if properly used in a well-designed engine, from 6 to 12 per cent should be amply sufficient.

In order to use as little water as possible it should be introduced in a finely atomized condition. It will then present the greatest cooling surface with the least volume. The necessity of using a minimum of water is apparent when we remember that in vaporizing, the water extracts heat from the fuel, so that for every ounce of water it takes about 5 per cent of that amount of kerosene to vaporize it. This fact is often disregarded and water is allowed to slug into the mixture in excess

quantities producing poor economy, missing and loss of flexibility. Since water in a finely pulverized state will absorb a large amount of heat, it serves as a very simple and effective means of lowering the mixture temperature and preventing preignition.

We have never been able to find any evidence that water had any appreciable effect either in the formation or removal of carbon.

Figs. 12 to 16 show the power and economy curves for four and six-cylinder engines operated on various kinds and mixtures of fuel.

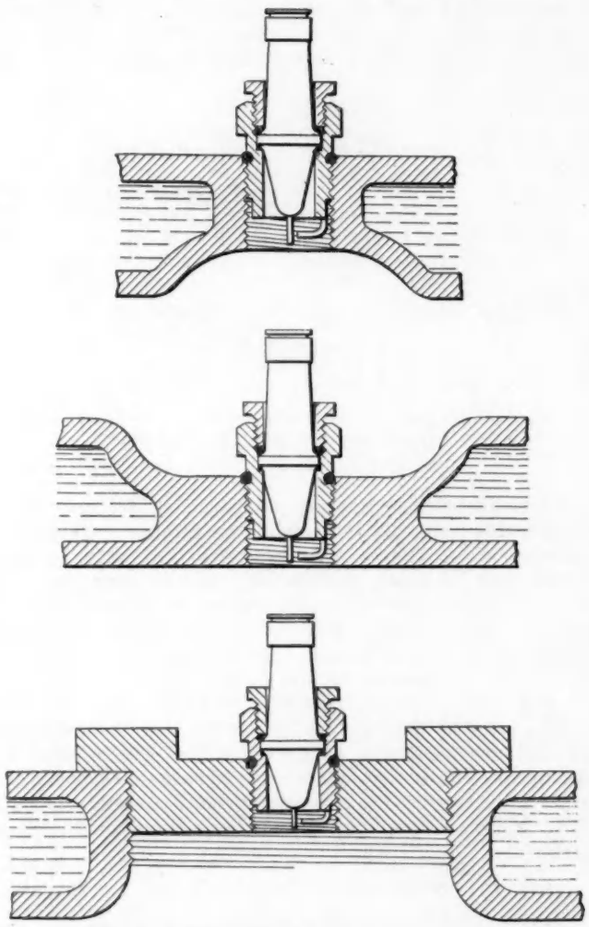


FIG. 9—PROPER LOCATION OF SPARK-PLUGS

EDUCATING THE USER

Still another factor must be considered in making kerosene tractors, and that is the ability and knowledge of the men who are to handle them in the field. It must be admitted that the very best of our kerosene tractors are not quite as easy for the average farmer to operate as the gasoline tractor; so that to insure the success of kerosene as a fuel we must go beyond the mere manufacture and marketing of the machine, and must instruct the owners and operators in the handling of low-grade fuels.

A good kerosene tractor in the hands of a poor operator will behave just a little bit worse than a gasoline machine with the same operator, so that it is our duty first to make our products as nearly right as possible,

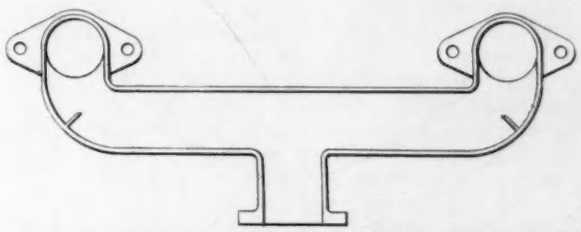


FIG. 10—MANIFOLD WITH BAFFLES TO PREVENT CONDENSATION

and second to give the farmer the benefit of our experience in using them. It is only in this way that we can hope to make the kerosene tractor the success it must become.

The trade papers are doing a great work along educational lines, but some of them have failed in one respect, and that is, in their evident failure to investigate the truth of their advertising. This has resulted in the publication of a great deal of misleading information especially concerning so-called kerosene-burning devices, some of which cannot possibly do what the advertisers claim for them.

The worst offenders in this class are those advertisers of kerosene attachments which guarantee to make a perfect kerosene engine out of any make or type of gasoline engine; this is obviously a misrepresentation of fact.

The advertising and sale of products that cannot be successful has done much damage to the reputation of kerosene tractors and to kerosene as a fuel. At this time it is a patriotic duty of every advertiser and publisher to make sure that he is not misleading the tractor-buying public. The trade papers with a little care can do much to eliminate this evil.

The thermodynamics and fundamental principles of carburetion have been presented and discussed many times by able men, so I have purposely refrained from a repetition of well-known facts as far as possible. Instead I have tried to put the kerosene-tractor situation in such a way that the members of the S. A. E. will endeavor more earnestly through the organization to effect the cooperation of the engine manufacturers, the tractor men, the accessory men and the trade papers; and by so doing hasten the development of what is now one of our greatest economic necessities, the standardized American kerosene tractor.

THE DISCUSSION

P. S. TICE:—The popular and outstanding distinction between gasoline and kerosene is the higher scale position of the boiling range of the latter fuel. This makes its handling by conventional methods, or an extension of

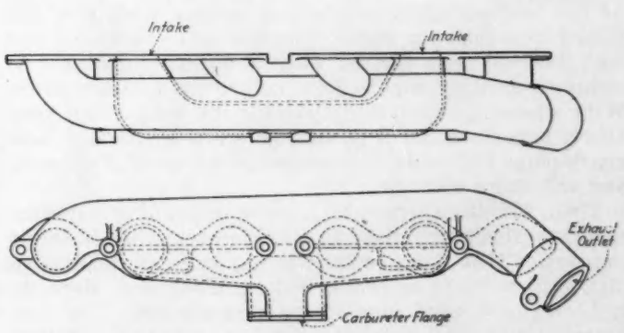


FIG. 11—COMBINATION EXHAUST AND INTAKE MANIFOLD FOR KEROSENE

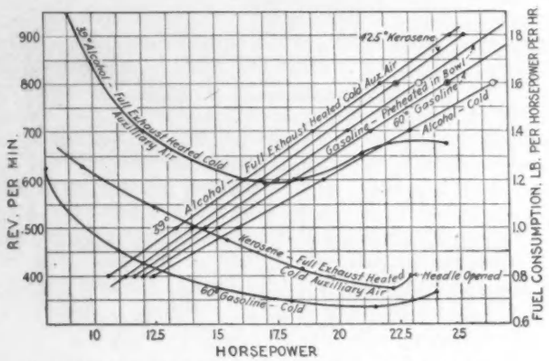

REV. PER MIN.
FUEL CONSUMPTION, LB. PER HORSEPOWER PER HR.
HORSEPOWER
42.5° Kerosene
39° Alcohol - Full Exhaust Heated Cold Auxiliary Air
Full Exhaust Heated Cold Aux. Air
Gasoline - Preheated in Bowl
60° Gasoline
Alcohol - Cold
39° Alcohol - Kerosene - Full Exhaust Heated Cold Auxiliary Air - Needle Opened
60° Gasoline - Cold

FIG. 12—PERFORMANCE OF FOUR-CYL., 4½ BY 5-IN. ENGINE AT 800 R.P.M. COMPRESSION 72 LB. WATER USED ON ALL LOADS ABOVE 18 HP.

conventional methods, of carburetion all but impossible, because of the inadequacy of common practices to satisfy the requirements for vaporization of this less volatile fuel. It is true that a sufficient extension of the methods of air pre-heating and hot-jacketing of the intake manifold will permit operation on kerosene to a certain degree. But when vaporization is secured in this way other difficulties and problems of a most serious nature are inherently introduced.

Constants for Gasoline and Kerosene

It is thought that a tabulation of the characteristic and pertinent constants of the two fuels will be the best way to approach this subject, afterward discussing their effects upon the result. Such a tabulation follows:

	Gasoline	Kerosene
Specific gravity	0.7300	0.8400
Specific heat	0.5055	0.4953
Latent heat of vaporization, B.t.u. per lb.	295	200
Sensible heat at mean boiling point, B.t.u., per lb.	75	220
Total heat of vaporization at mean boiling point, B.t.u. per lb.	370	440
Initial boiling point, deg. fahr.	65*	338†
Terminal boiling point, deg. fahr.	409*	544†
Boiling range, deg. fahr.	344*	206†
Temperature of ignition of mixture, deg. fahr.	680	575
Relative viscosity	0.64 to 0.72	1.10 to 1.70
Content of unsaturated hydrocarbons, per cent	3 to 5	8 to 18

*Red Crown. †Perfection oil.

Not only is the vaporization of kerosene somewhat more difficult of attainment than is that of gasoline, but it is absolutely essential that the process be completed before the entrance of the mixture into the cylinders, if satisfactory performance is to be had. The requirement in this direction is not so inflexible in the case of gasoline, since failure to complete the process before passage of the valves is necessarily attended by only a small waste of fuel and a slightly accelerated rate of fouling of the combustion-chamber walls. The heat of compression and that received from the hot walls is normally sufficient to complete gasoline vaporization before the ignition point. With kerosene, that portion wetting the walls is but very slowly vaporized, burns on the surface only, rapidly fouls spark-plugs and walls, is attended by a vaporous exhaust, and will cause missing.

Then, too, the appreciably narrower limits of satisfactorily useable proportions in a kerosene mixture make it imperative that there be little if any error in qualitative distribution to the several cylinders, if smoking, deposits and irregularities of running are to be avoided. The most practical way to guard this point is to make the mixture a homogeneous one in such a condition that its quality, as to the ratio at the several valve ports, is undisturbed by whatever branchings it is forced to make in its passage to the cylinders. With any intake manifold, this requirement presupposes that the fuel be in perfect entrainment in the air stream, and hence that it exist in the manifold either as a vapor or as a fog of minute particles formed by the total or partial condensation of the vapor. Neither the vaporous nor the foggy mixture gives rise to wall wetting and its attendant troubles.

The real difficulty in securing this initial vaporization of kerosene lies not in the requirement for heat to perform the actual evaporation, but in the requirement that relatively so much heat must be applied to bring the fuel

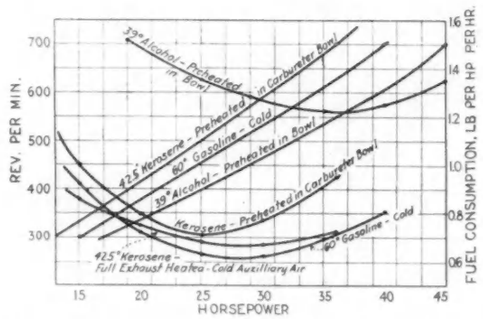

REV. PER MIN.
FUEL CONSUMPTION, LB. PER HP. PER HR.
HORSEPOWER
39° Alcohol - Preheated in Carburetor Bowl
42.5 Kerosene - Preheated in Carburetor Bowl
Gasoline - Cold
60° Gasoline - Preheated in Bowl
39° Alcohol - Preheated in Carburetor Bowl
Kerosene - Preheated in Carburetor Bowl
60° Gasoline - Cold
42.5° Kerosene - Full Exhaust Heated - Cold Auxiliary Air

FIG. 13—PERFORMANCE OF FOUR-CYL., 5 BY 7-IN. ENGINE AT 700 R.P.M. MAXIMUM POWER ON KEROSENE WITHOUT WATER, 30 HP.

to the temperature at which evaporation can take place at a useable rate. Reference to the figures for heats of vaporization of the two fuels shows that actually only 68 per cent as much heat is required to evaporate one pound of kerosene, as is needed for a like weight of gasoline. On the other hand, over three times the amount of heat as is needed in the case of gasoline is required to bring the kerosene to the condition under which it will vaporize. The total heats in the two cases, the sum of that needed suitably to raise the fuel temperature and that needed to evaporate the fuel at the raised temperature, are as 1:1.19, gasoline to kerosene, respectively. Thus it is seen that the problem is merely one of starting point; and so viewed, it presents no serious obstacles to a solution.

Self-Ignition Temperatures

Direct and conclusive experiments have shown that the most important of all points in the use of this fuel in present automobile-type engines is that of the end temperature of the mixture following compression. The experiments mentioned have had as their object the determination of the temperatures at which mixtures under compression will automatically ignite. So far as is known the first work to be done along this line was undertaken by, or under the direction of, Prof. E. B. Wood, one of the I. A. E. members, who visited us some years ago. Subsequent work has borne out his statement that gasoline mixtures of proportions useable in an engine self-ignite at a temperature of about 680 deg. fahr., while kerosene mixtures of like proportions self-ignite at about 575 deg. fahr. This is the cause of all the talk about pounding and preignition accompanying the use of kerosene in an engine having clearances suitable for gasoline.

It is interesting to check the limiting condition in this light. In the first instance, in order to remain within a given terminal compression-temperature with a given clearance ratio, a certain mixture temperature at the be-

ginning of the compression stroke must not be exceeded. But with kerosene fuel, a rather definite minimum initial mixture temperature, referred to the compression stroke, must be maintained if clean and satisfactory operation of the engine is to result. The method and apparatus I have developed for handling the so-called heavy fuels maintains a kerosene mixture at the substantially constant temperature value of 175 to 180 deg. fahr. over the whole range of operation, from idle to full load at highest speeds. This value has been found to be the approximate minimum that will permit of absolutely clean operation, and it is presented here as a starting point for the proposed checking of the approximate limit. Further it has been found by protracted cut-and-try methods that a clean engine having clearances to give 65 lb. per sq. in. gage compression pressure at the peak of the curve will operate on kerosene without any pounding or preignition, it being supplied with mixture at the noted temperature, measured at the intake-valve ports. From the equation for the adiabatic compression of air, employing the empirical value for k of 1.300, which is based on direct investigations of many engines, it is found that the terminal

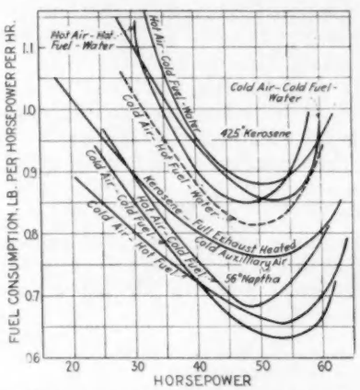

FUEL CONSUMPTION, LB. PER HORSEPOWER PER HR.
HORSEPOWER
Hot Air - Hot Fuel - Water
Hot Air - Cold Fuel - Water
Cold Air - Cold Fuel - Water
425° Kerosene
Cold Air - Hot Fuel - Water
Kerosene - Full Exhaust Heated
Cold Auxiliary Air
Hot Air - Cold Fuel - Water
Cold Air - Cold Fuel - Water
Cold Air - Hot Fuel
56° Naptha

FIG. 14—PERFORMANCE OF FOUR-CYL., 6½ BY 8-IN. ENGINE AT 650 R.P.M.

compression temperature with a clearance ratio of 4.08 and an initial mixture temperature of 175 deg. fahr. is 508 deg. above 0 deg. fahr., or about 70 deg. within the self-ignition limit.

So long as this engine remains clean, so long will it run without pounding. But as soon as a slight and inevitable deposit becomes granular and tends to scale, just so soon does self-ignition set in with fully opened throttle. It is then the old, old story of hot points persisting at temperatures above the ignition temperature of the mixture. The remedy is frequent cleaning of the combustion chambers, or a lowering of the compression ratio. Of the two the latter is the more reasonable and useful.

There is another and not infrequently encountered system of hot points to be contended with in the operation of kerosene in an engine. Those makes of spark-plugs in which provision is not made for a sufficiently rapid carrying off of heat from the electrodes are prolific trouble makers, and must be avoided in this service. Hot points of this sort are operative almost without respect to the compression or clearance ratio employed, and irrespective of the condition of the combustion-chamber walls. From this point of view, the best plugs obtainable are none too good.

Analysis of this condition seems to indicate that what has been termed self-ignition is not necessarily exactly

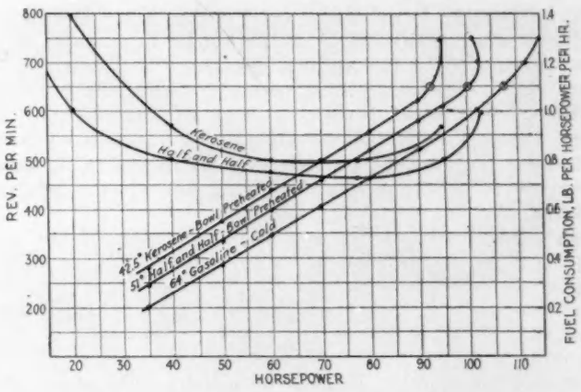


FIG. 15—PERFORMANCE OF SIX-CYL., 6½ BY 8-IN. ENGINE AT 650 R.P.M. WATER USED AT ALL LOADS ABOVE 75 HP.

describable in this way. With the compression ratio carried about to the limit, a frequent manifestation is not preignition at all, in that the engine will immediately cease firing upon opening of the ignition circuit, and the pounding is amenable to control by retardation of the spark position. But such retardation is usually accompanied by a loss of output, even though it is just sufficient to eliminate the pounding. The explanation seems to be that the whole mass of mixture is at, or almost at, the ignition temperature at the normal time of passage of the spark, and thus inflammation more nearly approaches instantaneousness than is ordinarily the case. This condition is more noticeable in an engine that is well worked-in than it is in a new one with all bearings and pistons snug. From this it seems that there can be a too rapid combustion of the charge. However, it is noticeable that this condition occurs in the mid-half of the speed range only, and is absent at both higher and lower speeds.

Value of Air Cleansing

To control or eliminate these difficulties, it has been proposed to supply water with the mixture. My experience in this direction is limited, but has been conclusive as far as it has gone, in support of the view that water injection does more harm than good and is extremely troublesome on a throttle-controlled engine. As distinguished from direct supplying of water, a method of humidifying the air seems to be of more than a little advantage; but in which of two directions it is difficult to say, since the apparatus used both humidified the air and removed deposit-forming dust and other matter from it. Of the two functions performed it is thought that

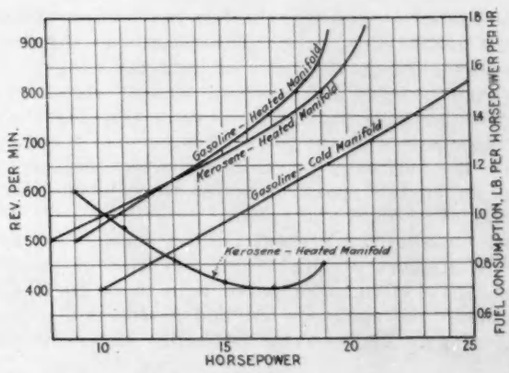


FIG. 16—PERFORMANCE OF FOUR-CYL., 4½ BY 5-IN. ENGINE AT 800 R.P.M. EXHAUST-JACKETED INTAKE MANIFOLD

the latter may be of the greater value, since it is conceivable that certain parts of the almost impalpable solid matter carried by the air may be raised to the temperature of its ignition by heat received within the cylinder before the time of proper ignition of the charge. If this occurs, the portion of the charge immediately surrounding the burning particle may be raised to its temperature of ignition, thereby firing the charge prematurely.

In farm work on dry soil such cleansing of the air aspirated by the engine seems to be imperative if cylinder deposits are to be kept down, and if long life for the engine is desired. In this latter connection it seems that the crankcase breather might well be connected with the scrubber.

Before leaving the subject of self-ignition, it should be noted that kerosenes bought in different sections of the country may behave quite differently under like conditions. For instance, on two occasions it seemed desirable to fill the fuel tank at a certain Michigan town, about midway across the State, where the only kerosene available is of a certain brand. Each time the engine had been running at its sweetest just before filling the tank; and each time, after taking on this particular kerosene, the engine had to be handled very gently to avoid pounding, as soon as the new fuel had displaced that in the float chamber. Examinations were made of this fuel on all conceivable points, and the only one to show an appreciable variation from normal was that for content of unsaturated compounds. This latter test disclosed that between 17 and 18 per cent by weight was unsaturated hydrocarbons. Normal or average kerosene will not show more than from 8 to 12 per cent of these components; and good gasoline never shows more than from 3 to 5 per cent.

Cracking processes of fuel production increase the proportion of these components; and it has for some time seemed reasonable to connect them with the increased rate of deposit formation in all classes of engines since these processes have come into commercial use. Furthermore, it seems that the experience cited following tanking in this certain town, supplemented by laboratory work with a generous sample of this fuel, tends toward the supposition that an increase in unsaturated hydrocarbon content in a fuel presupposes a lowering of the temperature of self-ignition of that fuel. Not enough work has been done in this direction to make the conclusion certain, but the evidence points in that direction. It will be interesting to hear of the experiences of others on this point.

Greater Flexibility With Kerosene

The tabular matter shows that the boiling range for gasoline is 344 deg. fahr., while that for kerosene includes but 206 deg., the ratio of kerosene range to gasoline range being 1:1.67. From this it seems evident that, with suitable provisions in each case for the complete vaporization of the fuel, the more nearly homogeneous one, the kerosene, possesses a distinct advantage for use in an engine operated under throttle control over wide ranges of loads and speeds.

To go outside the present subject matter for an example in support of this point, the case of denatured alcohol can be cited. Compared with other fuels, this is a practically homogeneous one and possesses a minimum boiling range. The extreme flexibility under throttle of an engine suitably carburetted with this fuel constitutes one of the major arguments for its production in great quantities and at a price that will make it available for general use.

It has been deemed necessary to include, in what should be a direct and unequivocal statement, the qualifying term "suitably carburetted." This is unfortunate, since it leaves the details of method undefined. It is safe to say that no two men, figuratively speaking, hold the same mental picture of method to follow in making an engine "suitably carburetted," or to broaden the case, "perfectly carburetted." Thus, our practice shows for what it is—a matter of many individual opinions—whereas it cannot ultimately, and perhaps should not now, be other than a matter of indisputable fact or of a group of indisputable facts.

Each of us must constantly refer his opinions and statements on the broader aspects of such a case as the present one to the apparatus with which his experience was secured; and the scope and value of our opinions are limited by the very limitations of the methods and apparatus giving us the experience. Thus, different methods and different apparatus lead to different experiences and often widely different conclusions.

A useful definition of the term "suitably carburetted" is that treatment of the fuel which causes it to be present in the combustion chambers at the time of ignition in that quantity and in that condition to cause its most complete combustion. For specific conditions the quantity, meaning the fuel-to-air ratio, may be varied to advantage, but the requirement of condition is inflexible.

General Conclusions

With the handling of the two fuels, gasoline and kerosene, falling within this definition of suitable carburetion, my experiences point to the following comparisons and conclusions:

(1) Thermal efficiency referred to indicated horsepower; kerosene from 2 to 4 per cent higher.

(2) Thermal efficiency referred to brake horsepower; kerosene from 4 to 8 per cent lower.

(3) Brake horsepower at peak of curve; kerosene from 8 to 15 per cent lower.

(4) Brake horsepower at medium and lower engine speeds; kerosene little if any lower.

(5) Flexibility under throttle; kerosene fully equal to gasoline, with a greater sweetness, as a result of lowered compression.

(6) Engine temperatures; kerosene shows higher maximum and terminal temperatures at the exhaust, but shows a correspondingly less loss of heat to the water-jacket. (See indicated thermal efficiency.)

(7) Kerosene suffers a greater change of viscosity for an equal fluctuation of temperature of the liquid, but the effect of this upon adjustment of the carbureter is offset by the nearly constant liquid temperatures maintained at all seasons in a kerosene-using system; hence the possibility and desirability of a fixed adjustment.

(8) Economy under part throttle; kerosene shows results in car miles or ton miles at all times equal to and often slightly greater than those attainable with gasoline.

Comparing a well-developed heavy-fuel system using kerosene with any conventional and largely used gasoline outfit, the results are all highly favorable to the kerosene, with the one exception of maximum power output. The points on which the greatest scorings are made by the kerosene are those of rapidity of coming up to normal operation in cold weather, economy of operation under any and all conditions of use, and last but not least, a marked general improvement in nicety of operation and in the all-around handling of the vehicle using it as fuel.

Exhibitor's Headquarters at National Tractor Demonstration

Problems of Tractor Service

By DENT PARRETT* (*Member of the Society*) *Illustrated with* PHOTOGRAPH

WITH our country at war, it is important that all methods of crop production reach a high state of efficiency. The farm tractor is the only solution to such problems as the demand for more power and the increasing scarcity of farm labor. The progress in tractor development is increasing the usefulness of tractors each year.

There are so many angles to the service problem that it is not possible to consider them all at this time. Certainly one of the most important points to bring out is the correct understanding of what is meant by the word service. From past experience it seems that the average purchaser thinks the word "service" means "something for nothing," when, in reality, it means giving the customer what he wants and needs in the quickest possible time, at the lowest possible cost.

We, in the tractor business, are really selling power to a farmer very much as a large public service company sells electric current. The tractor is the medium whereby we deliver this power. In selling tractors, if we cannot accept the obligation of furnishing correct information for using them, and adequate organization for distributing repair parts, we are not fulfilling our real function.

*President, Parrett Tractor Company.

Quick results can be secured by more intelligent operation of tractors already in use and now being manufactured. A large percentage of tractors are doing good work, but all would render even better service if properly operated and cared for.

The technical and farm press have accomplished much in telling farmers how to plan the work of their tractors, showing the importance of proper care and operation, and teaching the farmer to show the right spirit toward the machine. Stories of experiences in power farming can be made interesting reading, and offer an excellent means of teaching the farmer that his success with a tractor largely depends on his own efforts.

THINKING IN TRACTOR TERMS

The greatest present need is to educate the tractor owner to have the proper attitude toward his machine, and to feel his responsibility. He should be taught to think of the tractor in terms of tractor energy. He should realize that overloading and lack of proper care will result in less reliable service and in repair expense.

A good example is found in the experience of an intelligent and progressive farmer. He owned an automobile for several years, so, when he bought a tractor, was

confident he could take care of it properly. On the third day he telephoned for help. The service man sent to his assistance found the engine without oil. The owner said his automobile needed oil only once a week, and thought that often enough to put oil in a tractor. Fortunately, the damage was slight, and was very quickly repaired. He was then told that the manufacturer could build the tractor, but could not run it for him; he must do that for himself. This farmer learned two important lessons from this experience: to think in tractor terms and to realize his own responsibility.

Many purchasers and operators do not read the printed instructions. Owners who have the right attitude read instructions carefully, and refer to them in case of trouble. For the many who do not, some simple plan should be worked out to induce them to read the instruction book. The following plan was suggested, and is surely worthy of consideration:

Send out advice on care and operation in bulletin form, a part of which is detachable, to be filled out and returned to the factory. If it is not returned, the guarantee would cease automatically.

Prompt repair service should be a goal for every manufacturer. If the factory has the right viewpoint toward service, the whole organization will get the spirit of helping the tractor "do its bit." Repair parts should be located so that any owner can get them within twenty-four hours by express. This will save the loss of much valuable time, and build up public confidence in power farming.

Examples of Proper Service

Considerable progress has been made toward standardization by individual manufacturers, with the result that repairs are made more easily and with less loss of time. When the tractor owner can install repair parts without considerable fitting, his good-will toward the machine increases. I want to give the following examples of what prompt and efficient service has done for the tractor owners.

(1) One of the big troubles is that most owners have not learned to think of field work in terms of tractor energy. One owner will expect entirely too much, and another will expect less than the tractor is really able to do.

A farmer had been plowing with horses on some very wet land, and getting along fairly well. He purchased a tractor and tried to go out at once and plow on this same land. This farmer had the idea that, because the tractor was delivered to him in good shape, he should be able to run it day after day without a single adjustment, and have it continue to work perfectly. The service man pressed upon the farmer the fact that he must learn the adjustments of the tractor himself if he expected the best service from it. He also succeeded in getting the farmer to think of the tractor in terms different from those he used when thinking of horses.

(2) In many cases salesmen make extravagant claims as to the work the tractor can do. Very often this leads the new owner to expect entirely too much from his machine.

A dealer sold a tractor on a guarantee that it would pull its regular number of plows in 10 in. deep. The tractor was delivered at a time when the ground was very hard and dry, still the expert made the tractor do what was claimed by the salesman. This farmer had purchased it with the understanding that it would pull the plows in 10 in. deep, and he wanted to continue plowing at that depth. Furthermore, he expected the machine to do this work without care and attention on his part. The service man explained to this owner what he might expect from the tractor, and emphasized very strongly the duties of the operator.

The customer was brought to realize that his responsibility was as great as that of the manufacturer. He at once took a greater interest in his machine, and soon learned how to operate it better, and today this man is a tractor enthusiast.

(3) We usually expect more from the young fellow who has attended an agricultural college. However, here is an example of a graduate of one of our best agricultural schools, who had trouble with his machine. The tractor was shipped to him in the late winter before it was possible to try it out in actual field operation. The expert making the delivery gave all the information he could in regard to the care and operation of the machine. He left feeling satisfied that this new owner could get along all right.

As soon as spring work started this young fellow called for help. He was not getting along with his tractor—he did not consider it practical for spring work, and expressed his great disappointment in the purchase. The service man was sent at once, and spent several days showing the owner how to operate the machine, and what could be done with it. Since that time this young man has written several letters expressing his entire satisfaction with the tractor.

Teaching the Farmer

The manufacturer's service department should be organized with the main object of teaching the farmer to help himself. It is important that new tractors be started off in the right way. The operator should be taught how to care properly for the machine, and should be told the advantage of operating it within its capacity, instead of attempting to overload it.

The first step toward securing the purchaser's goodwill is that the tractor be sold on conservative claims. If he then receives the proper instructions, the new owner will be well started on the road to efficient tractor service.

The engine, transmission and other working parts will last longer if a new tractor pulls a light load for the first two or three days. Too often the new plowing outfit is put on the toughest piece of ground on the farm in order to try it out. Automobile manufacturers of long experience are sending out instructions with new cars that they should not be driven faster than 20 or 25 m.p.h. for the first few hundred miles. Tractor manufacturers and owners should take the lesson.

The operator should have a regular plan for oiling and caring for the tractor. Even though this work takes one-half hour from each working day, it must be done regularly, and will result in more reliable and efficient service.

Keeping in mind the viewpoint of better service from present tractors, we have laid special emphasis on the farmer's duties in operating farm power equipment. I believe the established tractor manufacturers are fully conscious of their great responsibility in producing more efficient tractors, and in greater numbers. With the farmer and the manufacturer each doing his full share, the resultant tractor service will go far toward solving the problem of supplying the food needed by the nation.

Governmental Tractor Service

By H. C. BUFFINGTON* (*Member of the Society*)

WITHOUT exaggeration, I believe 25 per cent of the tractors stand idle during the busy season, whereas they could be doing profitable work. There are, perhaps, 25 per cent more that could be doing profitable work, but are inefficient because of the operator's inability to handle them properly; another 25 per cent are not producing satisfactory results owing to lack of repairs, supplies, etc. If this is so only 25 per cent of the tractors are efficient.

The task then is to improve this condition so that all the tractors will give continuous, satisfactory, and profitable service.

Education can be carried on in many ways, through instruction books issued by the tractor manufacturers and universities (but the farmer seldom has time to read these), or through large tractor schools. But this is only a beginning. What we want is action now, and not efforts that will produce results two or three years hence.

We need a system that will carry tractor service, or, better yet, tractor efficiency, to the farmer's door, and not rely upon his coming to us.

We are making a great deal of fuss about the conservation of our food supply. Why not make more of a fuss about increasing the food supply? We have thousands of tractors, and thousands of square miles of fertile land. I believe there is one way of taking care of this problem, and that is for the Government to have a hand in the situation.

In order to work out the system, let us take one State, North Dakota, for an example, and create a new department. Call it the "Department of Tractor Service," for convenience, with headquarters at Bismarck. Then let us locate sub-quarters, all being geographically situated to cover the state effectually. Say, for example, Minot for the northwest, Devil's Lake for the northeast, Dickinson for the southwest and Fargo for the southeast. Next, employ expert field men, and assign them to certain territories.

The far-reaching scope and power of a body of men such as might be organized under this plan can hardly be realized until we go over a few of the items of information that could be gathered.

(1) The department would have an exact record of all tractors in the State.

(2) The department would know just when a tractor is standing idle.

(3) The department would have a record of farmers holding undeveloped land, land to break or seed, crops to harvest, such as the season, of course, would determine.

(4) The department would know the exact date on which a tractor was shipped from the factory, which road it would go over, and to whom it would be shipped.

(5) It would be a part of the department's duties to know why supplies of fuel, oil, or repair parts, were not taken care of promptly.

There is no limit to the possibilities of such a department's service under this system. All the work of gathering the necessary information can be accomplished without waste of time and space.

Organization of a Service Department

By L. B. DUNTLEY† (*Associate Member*)

IT will not be possible to give the tractor purchaser satisfactory tractor service until such time as tractors are sold to the ultimate purchaser for cash on delivery. This may apply more particularly to tractors selling for $2,000, or less, but the majority of tractors now sold are under $2,000, so let us deal with them.

The reason for this is found in the difference in the mental attitude of the tractor purchaser who pays cash and the one who buys on time. The cash purchaser owns the tractor from the start and naturally takes greater interest in it, with a greater desire to learn all there is to know about its operation and care than the purchaser who does not own the tractor until it is fully paid for. Until tractors are sold to the purchaser for cash tractor companies will be attempting to give service to two classes of purchasers who are not on an equal footing.

The object in organizing a service department is to group all activities pertaining to the welfare of the product after it is sold in such a manner that everyone concerned with that product will derive the greatest possible benefit. It will be more possible to organize the service department and gain that objective when the tractor companies have only one class of purchasers with which to deal.

The automobile companies giving service to owners have a definitely organized plan of operation, and they are really doing some splendid things. They have service stations established at their factory sales branches, where a car owner can take his car and have minor adjustments made. All car owners are on an equal footing, and how much better off they are as a result of that equality. When this principle is applied to tractor

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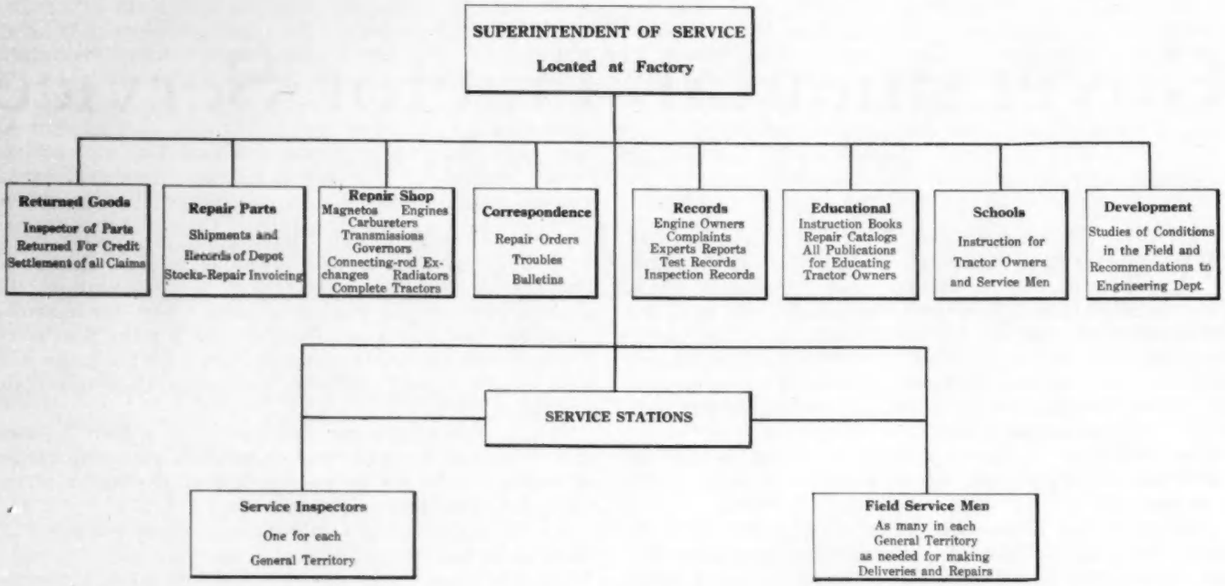


ORGANIZATION OF SERVICE DEPARTMENT FOR TRACTOR MANUFACTURER

service it will be given without any strings to it, and with no ulterior motives. The tractor owner is the one who will benefit most by such a system. He will be much better off and tractor service will be organized for service alone.

It will be impossible for tractor companies to organize service as it is organized by automobile companies; the car owner can take his car to a service station for repairs and inspection, but tractor service must be taken to the tractor in the field. It is seldom necessary for an automobile company to send a service man to a car located any great distance from a service station, because the local garage man will take care of the trouble. Not so with the tractor owner. Sometimes the garage man in the nearest town will be called upon for assistance, but the owner usually prefers to have a company man fix his tractor. This necessitates tractor companies working on an entirely different plan.

It is absolutely essential that tractor companies maintain service stations at centrally located points for the distribution of repair parts, but, in addition to that, they must maintain a corps of service men to visit the tractors. Tractor service stations are usually located at factory sales branches, if the company maintains such branches, or they may be established with a local distributor. These branches, however, are usually merely repair depots.

In the accompanying organization chart, it will be noted that a superintendent of service is at the head of the service organization and of all matters pertaining to service. He is located at the factory, and is independent of the sales organization. Here the tractor service department will differ from some automobile service departments. Many of the latter are operated in conjunction with the sales department, for, with their system of sales and service stations combined, one manager, with assistants, works out very well. In tractor service, with which a force of field service men is necessary, a department entirely separate from the sales department is almost sure to work out best, for there are so many things to combine with field service for the betterment of the industry as a whole that the burden of it all would be more than the sales department should bear if it is expected that justice to both sales and service will be done.

Treatment of Repair Parts

By return goods are meant all parts returned to the factory for credit in lieu of the warranty, and parts returned to be repaired and returned to the customer. This inspection could easily be taken care of by a regular factory inspector, and would not necessarily absorb all of his time. After the inspection, the written report of the inspector goes to the service department, and the claim is either allowed or rejected. Settlement of all other claims for non-performance, according to the warranty after the machine is delivered, will come under the service department.

All shipments of repair parts, records of repair stock, maintenance of repair stocks at factory and repair depots, invoicing and other routing work, comes rightfully under the service department. The fact that the service department is so closely in touch with the tractor owner at all times, and is so familiar with the work the machine is doing, its requirements and methods of repairing in the field, is the reason for its handling all this work.

Loose methods of allowing free repairs will undermine the correct principles of service about as quickly as any other one thing. Claims for free repairs should be settled absolutely on their individual merits and in accordance with the warranty. The cost of free repairs can easily be run into enormous figures when the production is large; the money spent for service is not then helping the tractor owner to the greatest extent. Tractor companies should insist that all claims on defective parts be accompanied by the return to the factory of all such parts. Such a system would soon form the basis for fairness in the settlement of claims.

Correspondence and Records

Service department correspondence will consist of instructions to field men and their routing; repair orders and correspondence incident thereto; letters to tractor owners regarding difficulties in operation of the ma-

chines; recommendations on care and operation, and on how to make repairs; and owners' bulletins pertaining to care and operation. The bulletins should constitute part of a campaign to educate tractor owners as to the correct methods of care and operation, and should consist of reliable information stated in plain language so as to be readily understood by persons not familiar with mechanics and technical terms.

It is essential to the welfare of the business as a whole that an accurate record be kept of to whom each tractor is sold, the serial number thereof, the purchaser's post-office address, his shipping point, and the dates of shipment and delivery of the tractor. A record of this kind greatly assists in the shipment of repair parts to the proper address, as well as in the directing of mail. It will also enable companies to circularize all of their tractor owners on any subject, and especially will help in the campaign of education.

All complaints on the product, classified and recorded in such a manner as to insure their receiving attention, will constitute a record of inestimable value to the engineering and production departments in their important work of developing the product.

Service reports, carefully filed and recorded, form a valuable record, as through this record, the superintendent of service can keep himself posted on actual field conditions, and thus be in better position to carry on intelligent correspondence with the tractor owner.

Records of tests on machines before delivery should be kept on file in the service department.

Educating the User

Some companies operate schools for the benefit of their customers and their own service men. These schools should certainly be under the direction of the service department.

All instruction books and other publications pertaining to the care and operation of tractors should be edited by the superintendent of service and published through his department. The instruction book should be in clear, concise language, and well illustrated with pictures and sketches, which will make the descriptive matter more easily understood. If the instruction book is made attractive, and is written in an interesting manner, the tractor owner will get something out of it. It should contain clear-cut recommendations, put forth in a forceful manner, and be a store of reliable information for the tractor owner. It should be arranged for ready reference, and of a size convenient to carry about.

The repair price list should be compiled by a person directly in charge of the repair end of the business. This list should contain the name of every part on the tractor, the pattern number and name, and should be so indexed and classified both numerically and alphabetically as to permit of finding any part readily. Each part should be illustrated, and, when possible, shown in its position on the tractor. The tractor owner will know a part by its picture and location on the tractor when he may not know it by name.

In listing gears, it is well to state the number of teeth. The sizes of belts, cap screws, spark-plugs and studs should be given. In fact, any details of description that will help to identify the part will be helpful.

A properly compiled repair price list will so aid a tractor owner in intelligently ordering repairs as to practically eliminate mistakes.

Service Department

A fully equipped repair shop, located at the factory, for the repairing of tractor units or even of complete machines and for making the minor repairs on accessories, would be a great asset to the department.

Service stations, so far as the service department is concerned, are merely repair depots and headquarters for the field men. It would probably be most practical to arrange for the actual routing of all field men by some one at the service station.

It will be necessary to have an intelligent man at each service station to take care of repairs and other miscellaneous matters pertaining to service, so that the work of routing the men would probably fall on him.

The duty of the field service man is to take care of the repairing of the machines in the field. If a tractor owner calls for service, a field service man goes out and puts the machine in running order. During the rush season, when tractors must be delivered to the purchaser, the sales department can requisition field service men from the service department to make these deliveries. While making deliveries they should be considered a part of the sales department, for a sale is not completed until the delivery is made.

One of the greatest services a company can render a purchaser is to send a man at the time of delivery of his tractor to instruct him in its correct care and operation, and leave him understanding all of the vital matters pertaining to the care and operation. If the purchaser is started right, he invariably gets along without trouble.

The sales department sells the tractors, but the service department must keep them sold by giving the tractor owner satisfactory service at the time it is needed.

Duties of Field Service Man

The field service man, to be a good one, must be a trained mechanic, with the natural ability to find trouble and remedy it. Working as he does, almost wholly on his own resources, he must be conscientious and thorough. His personality must be pleasing, and he must be diplomatic. In fact, he must be a high-class man. Some tractor owners have had some very unsatisfactory experiences with service men who were unfitted for that class of work. Tractor companies, therefore, should select their field men carefully. They undoubtedly will be forced to train men especially for this class of work.

The field service man must know the system thoroughly under which his company is giving service, and must guard himself against loose talk that might lead the purchaser to believe that he is entitled to many things which he is not.

He should be able to render complete and intelligent reports on everything that he does in connection with his work, and thus assist in developing the tractor. This does not mean that he must be an inventor or a designer. The fellow who thinks he is an inventor or designer does not, as a rule, make a good service man.

When all questions of service are finally solved and tractor service becomes well established, we will have taken a great step in advance, and the tractor industry, as well as owners of tractors, will be greatly benefited.

Tractor Service from Three Sides

By FRED P. STEELE* (*Associate Member*)

HAVING been in the tractor business for less than a year, I do not believe myself an expert on what tractor service should be. Having been in the automobile business since its infancy, however, and seeing service rendered from the three sides, manufacturer, dealer and owner, I do know that one of the reasons for so many failures among manufacturers and distributors, as well as among the small dealers, was due to the abuse of the word "service." Therefore, it is my presumption that we wish to avoid as many of these evils in the tractor industry as it is possible to do, and still give good, substantial service.

The word "service" has been much abused. Service does not mean giving something for nothing as so many farmers have been led to believe; it does mean, I believe, giving the maximum of care to our products in the hands of the ultimate consumer at as low a cost to him as possible. However, the manufacturer and dealer who employ men for this service are as much entitled to a legitimate profit on their time and trouble as they are to future profits (I say *future* profits advisedly) and as they are to profits on their original investment in grounds, buildings, machinery, and on other moneys expended.

As a sample of what some farmers think (or want us to believe they think) is the meaning of the word "service," the following is a true statement concerning the owner of one of our tractors. This man has a farm ninety miles west of Chicago. He telephoned our plant at Indianapolis that his tractor refused to run satisfactorily, and he must have a factory man at once, as he had only had the tractor a few weeks. We asked him his troubles, and he stated he did not know. He also asked us to send a cylinder-head gasket with this man. This farmer had owned two other tractors previously, and still he stated he did not know the trouble. When our man arrived at his town with his kit of tools, he said, "Well, you won't have to go out to my place. All I wanted was that cylinder-head gasket, and I knew if I telephoned for a man you would get here quicker than the express." We sent this man a bill for our expert's traveling expenses, not for his time, which we also really should have done, and this farmer refused to pay the bill, saying he had received this service free from the manufacturers of the two tractors he had owned.

It is hard to believe that he continually received such service free, but, if so, it is the evils caused by such ridiculous claims for service as this that must be remedied.

On the other hand, there is the irresponsible manufacturer, who promises anything and instructs his salesmen to promise anything both to the dealer and ultimate consumer, and forgets these promises immediately when his tractor is delivered and paid for.

The problem of the irresponsible dealer is, perhaps, the hardest to which to find the solution. He will promise anything and everything, and when these promises cannot be fulfilled, he will blame their nonfulfillment on the manufacturer of the goods, who is not to blame, but who, in the end, will be blamed by the ultimate consumer.

The responsible manufacturer and dealer sit idly by for a time and see the irresponsible dealer and manufacturer reap the early harvest. The latter, of course, will finally come into their own. In the meanwhile, however, the responsible manufacturers' and dealers' salesmen see the fly-by-night manufacturers and dealers doing a large business on promises that will soon be broken, and, in their anxiety to secure this business, they become overenthusiastic, and will sometimes make very broad promises. These, however, are invariably lived up to by the responsible manufacturer or dealer whose salesmen make them, but at a tremendous cost that can be avoided if some means to do so are adopted at once.

*Manager Tractor Department, Lyons Atlas Company.

Standardizing Tractor Parts

By GEORGE T. STRITE† (*Member of the Society*)

UNDER the present system every tractor manufacturer must add to the selling price a certain amount for service; a certain amount that he must practically lay aside to spend in service to tractor owners. Each farmer who buys a tractor pays for this service when he buys his tractor. Three-fourths of the owners do not use this amount of service, while the other one-fourth use enough more to make up for the others. If this charge could be equally distributed it would be fair and just; but it is not.

I know of one case when four tractors were sold and shipped at the same time, all being alike. The amount of service furnished to each of the four owners, A, B, C and D, after one year's time, was found to be as follows: A had used about $10 worth of service, B $5, C $15; D had been continually in trouble. The company had sent many men and had spent more than $170 on D. The company at that time figured to spend on an average of $50 per machine in service. In this case D had used nearly all of the service for which A, B and C had paid. The tractor that D owned was sold to another farmer who repaired it at his own expense, and broke nearly all records. This is only one case in hundreds.

If these tractors had been sold for $50 less to each man, farmer D would never have asked for the amount of service he received. Engine and tractor experts in almost every small town can, if the farmer will call on them, do the required work for from one-fifth to one-tenth the actual cost to the manufacturer, if the latter is required to send a man from the factory.

†Consulting Engineer, Minneapolis.

It would seem to me that the Society should have a tractor service committee and an instruction book could be published and sold. This committee could have a board of examiners, and possibly issue S. A. E. service buttons, or something of the kind, to service men who could intelligently answer a set of questions. A complete record of capable service men should be kept by this committee and should be of considerable value, especially so if the government should decide to take up the tractor service proposition, thus requiring a large number of men.

Quick, reliable repair service is one of the most important subjects in the tractor game. This is one reason the Ford car is so popular; any repair for a Ford car can be obtained anywhere at any time, and at a low price. The best way to facilitate the matter of tractor repairs is through the standardization of parts. A great many parts can be made and tractors can be slightly changed, so that these parts will fit many different makes of tractors.

Value of S. A. E. Standards

I firmly believe that we will carry the standardization work in tractors far beyond what the Society has been able to do with the automobile. The standardization work with the automobile has been carried much farther than with any other manufactured machine in the world, but why should we not go even farther? We have all the advantages of what the S. A. E. has learned in standardizing the automobile and truck parts.

When the Society started it did not have the prestige and power that it has today. No one man, or no one corporation, in the world has power or prestige enough to bring about these standards. There is only one organization in the world big enough, with prestige and the ability, to bring about these standards. This organization is represented by three letters, the most important letters in the alphabet—S. A. E. We are proud not only of the prestige, but also of the straightforward, honorable reputation and achievements that these letters represent. It will not be long until we will emphasize the fact of the number of S. A. E. standard parts used in tractors. We will see at every country town and village on the sign above the door, "S. A. E. Tractor Parts Sold Here."

When this is done it will not be long until the manufacturers will get in line; they cannot afford to do otherwise. Every purchaser will ask the question: How many S. A. E. standard parts are in this tractor? Everything else being equal, the purchaser will buy the machine that has the largest number of standardized parts, which he knows he can get almost anywhere at any time, and of a recognized quality.

One of the great benefits of the standardization of parts is the fact that, by so doing, the manufacturer can manufacture more cheaply, the farmer can buy more cheaply, the distributors and dealers can carry repair stocks to accommodate all machines with from 10 to 20 per cent of the actual investment that would be necessary without standardization.

Work of Recommendations Committee

In the Minneapolis Section of the S. A. E. we have a committee which is now called the Recommendations Committee. This was formed for the purpose of aiding the Tractor Standards Division. Many of our engineers are designing new machines and redesigning old machines, and they were continually pressing us for information. Therefore, it was decided to get up data sheets, not of standards, but of recommendations. I believe this will be of great value, because it will get the engineers accustomed to certain uniform sizes, so that the Tractor Standards Division of the parent society can take up these sizes, and formulate the proper standards.

Connecting-Rod Bearings

One of the subjects taken up by this committee is connecting-rod bearings. It was found that the crankshafts in the four-cylinder tractor engine vary in diameter from 1⅞ to 2¾ in. The committee has practically decided, if agreeable to the manufacturers, to recommend to the engineers that, in designing or redesigning engines, one of the following bearings be adopted for connecting-rods:

Diameter	2	2	2	2¼	2¼	2¼	2¼	2½	2½	2½	2½
Length	2¼	2½	2¾	2½	2¾	3	3¼	2¾	3	3¼	3½

This will mean fourteen bearings; probably eight or ten of these will eventually be the popular sizes. The engineer can choose a light, a medium, or a heavy bearing from the above bearings for almost any size of engine. The size of crankshafts and bearings now increase by 1-16 or 1-8 in. These the committee wishes to cut out and jump by ¼ in. only, in both diameter and length of bearing. The radius of the fillet and the distance from the end of the bearing to the side of the connecting-rod can be the same in all bearings. The thickness of bearing metal can be the same in the 2 and 2¼ in.; it will probably be 1-16 in. thicker in the 2½ and 2¼ in. bearings. This will give a uniform diameter for the bore in connecting-rods. I firmly believe that we can cut out the odd diameters in connecting-rod bearings and have probably three or four different lengths.

It would seem to me that the Standards Committee should give, for instance, to each bearing, a certain number, or a certain code word, whereby there could be no mistake in filling orders. There should also be some system by which the quality of material could be designated in, for instance, S. A. E. bearings. The manufacturer should be compelled to stamp his name, or trademark, on each bearing. We must have standard uniformity of material, as well as standard sizes.

Size of Tractor Engines

The committee has had many discussions in regard to the sizes of tractor engines. In the small tractor of today, four-plow and less, we have suggested five sizes, as follows:

Rating, Hp.	No. of Plows	Drawbar Pull, Lb.
8-16	2	1,200 to 1,500
10-20	2 to 3	1,500 to 2,000
12-25	3	1,800 to 2,400
15-30	3 to 4	2,200 to 2,800
20-40	4	2,500 to 3,500

There are today in the United States probably between twenty-five and fifty different sizes of tractor engines. It seems to the committee that this can eventually be decreased so as to be something like the above sizes.

Tractor Wheels

There are now many different sizes of tractor wheels. The committee has gone into the matter carefully, and has practically decided to recommend the following: Diameters, 48, 54 and 60 in.; widths of drive-wheel, 10, 12, 14 and 16 in.; thickness of rims, ⅜, 7-16 and ½ in. On account of the tendency at the present time to do away with the exposed bull gear in the drive-wheel and to

use an internal inclosed gear, or direct drive through the axle, it was decided not advisable to make any recommendations as to the size or style of spokes, hub or bore of hub of the drive-wheel at this time. This committee has prepared a table of recommendations also for front wheels.

Object of Standardization

The great object of the above recommendations, and of the work of the Standard Committee, is not to design parts, but to decrease the number of different dimensions of parts, eliminating the odd sizes, to bring all parts down to the lowest possible number of sizes, and still be able to take care of all the different loads and conditions. As, for instance, the above connecting-rod bearings. Such standardization will enable manufacturers to manufacture bearings at much less cost than they can now be made.

We must be sure that the Tractor Division of the S. A. E. Standards Committee will do nothing to destroy but do everything possible to preserve the present honor and dignity of our name; through the standards work we will have our name above the door of tens of thousands of the best and most responsible distributors, dealers and service houses, we hope, all over the world.

Tractor vs. Automobile Service

By S. C. Turkenkoph* (*Non-Member*)

TRACTOR service, like charity, should begin at home. By this statement we mean that it is impossible for any manufacturer or dealer to render efficient tractor service, no matter how excellent an organization he may have, without intelligent cooperation from the farmer owner.

Few farmers or dealers realize the amount of work the tractor engine does every day it is used. For the sake of comparison, say that the average tractor engine works at 75 per cent of its total capacity, then the engine in an automobile works at only 25 per cent of its total capacity. On many tractors the engine makes 25,000 revolutions per mile to 2,500 revolutions that are made by the engine in an automobile.

It has been said that one hundred working days represent the maximum time that a tractor will be used per season. In one hundred working days of ten hours each the engine in a tractor does work equivalent to that done by an engine in an automobile driving 25,000 miles. These figures show that timely and proper service must be rendered by all legitimate tractor manufacturers and their dealers.

We are familiar with the amount of repairing necessary to maintain an automobile for a distance of 25,000 miles. Will not the tractor, in the same time, require as much, if not more, repairing than an automobile? Tractor dealers must maintain efficient tractor service organizations that not only are able to do any mechanical work necessary on tractors in use by their customers, but also possess sufficient knowledge, or tractor education, to impart to the owners complete knowledge of tractor care and operation. This means much hard work, but, on account of conditions, and of the fact that the tractor is practically a new invention, we can see no other way by which the farmer can have service.

An automobile should and does require more attention during the first five hundred miles that it is in use than it does for the next three or four thousand. The tractor covers in the first two or three days it is in use what is equivalent to five hundred miles' travel of the automobile. It must have careful and exact attention over that period.

When a tractor is first put into service the conditions are entirely different from those present when an automobile is first put in service. In many cases the automobile is sold to a man who has never driven one. He naturally drives slowly and carefully until he has learned to operate. During this period his engine is "wearing in." Also because he drives so carefully he covers but a few miles per day, and the engine can "cool off"—recuperate as it were.

How about the tractor? It is delivered to the farmer who has told John, Bill and Jim that he has purchased a brand new tractor, and that the man is bringing it out to start plowing. All the friends and the family gather around to see her go. Either the farmer, his son or the dealer's operator gets on the machine, and the farmer says "drop her in." The operator drops down to four or five inches in depth. Some one asks the question, "Won't she go deeper than that?" Down goes the plow another two inches. Finally, after the first few minutes, the tractor is lunging across the field at its maximum speed, the plow is down to the extreme depth. It must go ahead and work without relief or rest for ten hours, or an equivalent of two hundred and fifty miles of car driving. If it does not do this then it is no good, and the farmer is ready to take it back to the dealer.

Service, like charity, must begin at home. The dealer must be able to instruct properly the owner to handle the tractor, teaching him at the beginning why to expect only the reasonable things, and to treat the machine as kindly as he would treat its equivalent in fine horses, or the real cash.

As every hour the tractor is driven means driving an automobile twenty-five miles to a garage or service station to see what is the matter with it, we can readily see that it is impossible or impracticable for a dealer to render efficient service on a tractor that is in use. How long will a connecting-rod bearing last in a racing engine or one working under heavy duty after it has developed a knock? How is it possible for the dealer, or his man, to be always on hand to place the "stitch in time" that will save the nine hours' work that the farmer is sure to lose before anyone from the dealer's establishment can be on hand and make repairs? It is all the more impossible for the manufacturer to render mechanical service that will be productive of satisfactory tractor operation. If a machine has been permitted to reach the point so that it breaks down, and must have new parts installed to put it in working condition, the manufacturer or the dealer can take care of the case after a reasonable delay. Our experience has taught us that

*Tractor Sales Manager, Moline Plow Company.

it is not repairing break-downs that constitutes real service; it is the odds and ends of upkeep and care that enable tractors to work continuously and give entire satisfaction without being laid up for repairs.

Educating the Farmer

Not even the dealer, much less the manufacturer, can be present to render this sort of service. Then how is service to be given? The farmer must be so well versed in tractor operation and repairing that he can keep his machine in condition, devoid of trouble by the "stitch in time" which is the basis of all real service. This sort of service can only be obtained by the manufacturers teaching their dealers all the points of tractor operation and repair, the dealers, in turn, teaching the farmers.

Another indirect angle that has bearing on efficient service is the tendency of all salesmen, and, I might add, of a few manufacturers, to over-sell their machines. Over-selling as the result of extravagant claims is probably one of the chief causes of dissatisfaction. It is the natural inclination of salesmen to follow the easiest course, to float down-stream. He finds out what the farmer wants the tractor to do and tells him that his tractor will do it. But, when the farmer gets the machine and finds out that it is not what the salesman lead him to believe he is somewhat disgruntled and begins to pick it to pieces. An effort by all manufacturers to hold the claims made in advertising matter or by their travelers to a reasonable point or below what the tractor really will do will not affect sales, and will still permit every tractor to give better service.

We should lend every effort to hold our advertising managers, our travelers and our dealers in check. Avoid making extravagant claims that cannot be proved in actual work, and which, in most cases, are absolutely unnecessary.

It would be an ideal condition to have all farms standardized, so that, if a man sent specifications covering the farm he owns, all that we would need to do would be to fill them. Standardization would add greatly to the success of tractors, but we believe that before an attempt be made to standardize farms or standardize their owners, or, for that matter, standardize types and sizes of tractors, we should standardize some of the easier and important items, namely, belt speeds, horsepower and belt-power ratings, and other similar things that are necessary to produce better service to the purchaser.

We are in an age where cooperation will be productive of monetary gain to all who are engaged in the tractor industry. Good service to users will increase the demand for our product. It will permit the farmer to go to a dealer and say, "My neighbors own four or five different makes of tractors, and they all give good service. I don't know which one I like best."

We should all work together and exchange service ideas that have been found to be practical. This can but lead to better business and less trouble to all.

Free service in all lines is at its zenith. We predict within a few years all tractor makers will be giving less free service, and teaching the purchaser that at least a part of the responsibility is his own.

Tractor service, like charity, must begin at home. We must teach the farmer to take care of his own machine if we want him to have real service.

Service as a Useful Office

By E. L. Woods* (*Non-Member*)

I AM neither an engineer nor a tractor manufacturer, and what I have to say will come from my experience in the sale of tractors. Here are two definitions:

Service—A useful office.

Tractor Service—A useful office for tractor owners.

To be of service to a tractor owner does not mean that the manufacturer or dealer must donate repairs or mechanics' time that involve a direct outlay of money. That is not service. That is equal to a cut in price. If one man buys a tractor, and, owing to his limited knowledge of machines, he has to call on the manufacturer or dealer for help, and some one is sent a few hundred miles to do several days' work for him free, it is equivalent to giving that man the $100 or $200 that the trip and repairs cost. It would have been just the same had we given him a rebate when he purchased.

Smith, his neighbor, who bought the same machine, and paid the same price, was capable of operating the machine, and did not have to call for assistance; therefore, we did not spend money on him, and Smith did not get as good a deal eventually as his neighbor.

If the manufacturer is adding enough to his price to send mechanics over the country on call, furnish free repairs, and, in some cases, pay the farmer for lost time, he should make this addition to his price a discount to a man who does not have to demand it. On the other hand, if the manufacturer is not adding this to his price, and keeps doing it, that manufacturer will be one of the missing members at the 1920 demonstration.

Service—a useful office, is much needed in the tractor business today. It should start in selling the contract to the dealer. The sales representative should canvass the matter of service in making contracts so that the dealer will have a clear understanding of what he is undertaking to sell. A salesman should, if anything, wave the flag of caution plainly at that time, so that the dealer will not over-sell one of the tractors.

The dealer and the traveler should not speak of the number of plows, capacity, inches deep, size of grain separator, etc., in positive statements. It is all right to maintain that, should the conditions be favorable, the tractor will pull a certain size of machine, or a certain number of plows, but the tangible facts should be that this machine will develop so many pounds at the drawbar, or so much power at the belt, and then, as in buying a horse, the farmer can utilize that power as he may see fit, either pulling one plow 12 in. or three plows 4 in. deep.

If the dealer is made to believe that the machine will do anything, he will make promises that will cause the manufacturer to cut the price several times before he ships him the second tractor. The manufacturer will have to keep the promises by sending men there to fix the tractor

*Manager Tractor Sales, J. I. Case Plow Works.

after it has done impossible things, or to talk the dealer's customer out of wanting the machine to do impossible things.

The next necessary step of tractor service is to acquaint the farmer that he is not purchasing Liberty Bonds that will just pay a dividend without any worry or taxation, but that he has purchased a powerplant that is worthless, and worse than worthless—like a compound interest note unpaid—unless it has an operator. The new owner should be carefully informed about every detail of his machine, and with the items of expense for repairs if it does not have the right attention. All this should be emphasized so earnestly that in running that tractor home he will not run over 1½ m.p. h. if its possible speed is 2½ or 3, or in plowing the first acres he will plow five acres a day if it will comfortably plow ten, that, in starting out, he will be so intent on listening to the engine that he will stop every mile and look it over for fear it might run out of oil or break something.

If we can get the owner in that frame of mind we need not worry that he will have any serious trouble, for by the time that he gets comfortably acquainted with his new purchase he will notice in a moment if there is a new noise in the engine, or if something is loose, and will fix it before it gets worse. If he is so constituted that he cannot acquire this he will become so worn out that he will hire a driver or sell the tractor.

I know men that were raised as farmer boys who caused their fathers so much expense each year on account of their carelessness or inability to handle horses, their breaking tools, leaving gates open, that he could not afford to keep them on the farm, and yet those same boys are at the head of professions to which they have turned their attention, and are successful men. I say, therefore, that all tractor owners will not make successful tractor operators. For the good of the industry, when we find one of these fellows, let us get our tractors out of his hands, or get him to hire a successful operator. If we get the machine out of his hands let us warn others so that they will not sell him another unless he gets an operator. His business will not be worth the price that it will cost us finally in that locality.

The manufacturers and dealers should keep tractor operators in mind, and in a case such as has been referred to should be able to furnish an operator that would be successful, and, by so doing, turn this dissatisfied owner into a tractor booster.

Necessity of Expert Operators

Dealers should always be on the lookout for young men mechanically inclined that would make good operators, and do everything possible to train them so they can be recommended as operators. There is going to be a call for such men and they will not have to work cheaply, either; but they must be capable of operating machines efficiently. By efficiency we mean constant, dependable work for nine hours out of every ten hours called for. If a farmer will pay a man $30 to $40 per month and board to work his farm with horses, and tend to them, he will not be unwilling to pay $100 or $120 a month to a man that can take the place of three or four regular farmhands and all their horses. He will then be saving the additional men's board and horses' keep. So, if the manufacturers and dealers will turn out the right kind of operators there will be a good call for their services.

There are many ways to accomplish this through other sources than the manufacturers or dealers. The agricultural schools are doing good work, and could do more by giving their students more field experience. The automobile schools are giving tractor instruction, and are doing some good work. Their pupils also need actual field experience. A great many automobile distributors are lining up their organizations for tractors, and they will, with the help of the manufacturers, make a good many tractor operators from automobile mechanics.

The young man that goes to the agricultural college spends his money to get the education that he is seeking; if he goes to an automobile school he also spends his money, but the farmer with no tractor experience buys a tractor and expects the manufacturer to furnish him this education free of charge.

To make a good operator from the average farmer over thirty-five years old, who has had no automobile or tractor experience, is surely difficult, and will take many trips of the service men. To produce results, that farmer should be made to pay for the trips. If Mr. Jones allows his gasoline to run out, and he calls the dealer, who drives five miles to discover it, he should not be permitted, because he is a good friend or customer of the dealer, to join him in a good hearty laugh, and let it go at that. He should pay well for that trip, and the next time that the engine stops he will look at the gasoline supply the first thing.

Obligations of the Manufacturer

Manufacturers' contracts, and their representatives, have made many dissatisfied tractor owners in the past, and it is time to concentrate effort to eliminate the trouble. Here are a few of them: Over-rating in catalog or in contract; over-selling by verbal statements; free repairs and free service. If we get all of the tractor manufacturers to eliminate these things we will then have tractors that will give satisfaction to 80 per cent of their owners, and that is a good percentage of satisfied owners for any industry.

The manufacturer has an obligation in tractor service, and, to my mind, it consists of the following:

(1) He should have all kinds of repair parts at his factory, and should never, no matter how old the machine, or what the part wanted, be out of them, but should be able to ship promptly any part required, for any machine he ever built.

(2) He should keep repair parts in the territory where he is doing a good business from year to year, so they will not be over twenty-four hours by express away from his users.

(3) When he is called upon for a service man that will be paid for by the customer, he should send one who has proved competent to do the work in the least possible time and in workmanlike manner, thereby saving the owner in labor and hotel bills. That man should be equipped with the necessary tools to do a field job.

(4) The manufacturer, for his own record, and to give the tractor owner real service, should maintain field men, whose duty it is to visit annually, every tractor of that manufacturer's make that is in the field, and submit a report over the owner's signature of its condition. This service man should counsel with the owner as to the condition of the machine, as to what should be done to get it into shape for the coming season's work, and, if necessary, write out the order for repairs for the owner so there will be no mistakes, and advise the owner of any mistakes he is making. In other words, check him up and try to make him a better operator. Such a man will make money for the manufacturer, the farmer, and for the dealer, and that is truly service—a useful office.

DISCUSSION OF TRACTOR SERVICE

MR. MOLLENAUER:—I wish to speak from a dealer's standpoint. In my territory I absolutely solved the service question. I never made my customer believe that he could put the machine I sold him in his field and let the engine do the rest. I never made him believe I would give him something indestructible, and I have found the solution.

I sold an outfit of spare parts with every tractor, and I found that a satisfactory solution of the service problem, for if something broke, the owner replaced it.

I would send out my men to see whether the owner got a sufficient amount of work from his engine and that he handled his engine right, to see that he got proper service from so-and-so many gallons of gasoline.

But if he broke a part from neglect of oiling or any kind of neglect, I never gave free service. I think that it will be easy to introduce this custom with harvest machinery, to sell extra parts.

CHAIRMAN FRED GLOVER:—Mr. Mollenauer had a great deal of experience in selling tractors in Europe before the war, and when the war broke out he mobilized for his country all the tractors available there—several hundreds of them—and he knows what he is talking about.

L. B. DUNTLEY:—The general opinion seems to be that the one greatest question in connection with service is that of educating the farmer in the correct care and operation of his machine. This can be accomplished in many different ways, and already a great deal of work is being done. The trade papers and technical publications dealing with tractors could be of great help.

I am sure that a number of men are sufficiently interested in tractor service to cooperate with these papers in writing articles. These articles would necessarily be of a general nature, pertaining to the care and operation of the tractor, and I am sure that the farmers would be glad to read them.

They would reach not only the farmer, but also the dealer, the salesman and the field service men, and practically every one interested in the subject. The dealers selling tractors certainly need to be educated, nearly as much as the farmer himself, because if a farmer buys a tractor from a dealer he naturally depends on that dealer a great deal to help him out of any trouble. He would much rather talk his troubles over with the dealer whom he knows personally than write a letter to the tractor company.

RAYMOND OLNEY:—I have been interested in the suggestion for cooperation from the trade and farm press. Speaking from the standpoint of our own publication, we are always glad to cooperate in this way. We have been devoting a great deal of space to the service end of the industry, realizing that it is one of the most important factors in the success of the tractor on the farm.

We would like to give more of this cooperation, but we need and will expect the cooperation of the service departments of the tractor manufacturers. Manufacturers are organizing effective service departments, and we need their cooperation in publishing material that will help the farmer to make his tractor more efficient.

E. J. SWEENEY:—I have been teaching this business many years and have taught about fourteen thousand men. About four years ago I thought I had taught all the men in the country the automobile business, so I went into the tractor manufacturing business. I bought the best materials obtainable and built a machine. I had everything in it except brains.

I quit the tractor business and put a million dollars in a school because I figured there was a bigger demand for teaching than there was for the tractors. The tractors would not run unless the men knew how to run them. I was paid last year by the farmer boys of this country over a half million dollars for a tractor education. In addition to that they spent another half million supporting themselves while in school.

The tractor manufacturers will hardly deny that ninety per cent of the causes of their sending out so-called service men is due to the lack of experience or education of the operator, not to the fault of the machine; and about ten per cent to the construction of the machine. Then let us work on the long end of it, the ninety per cent end, the education of the men.

From the time the man buys the machine until he gets it is the time for the educational department to send him bulletins, and little working models of the machine. He will devour and read everything before he gets his machine, but he will not afterward. I know this, because I have overhauled thousands of automobiles and in the bottom of the tool box found the instruction book down with the waste, all greasy and oily. The owners have never read it.

Prevent breakage instead of going after it and fixing it up. I believe that should be an educational proposition instead of service. The manufacturer can do it, and that is what he will have to do. That is the solution of the problem instead of service—education!

PROFESSOR THOMPSON:—Service in Oklahoma, I believe, is just as much needed as service in other parts of the country. Some of the companies are, of course, sending around service men, and they are welcomed by the farmers, but I believe that, as has been mentioned, the great thing which will gradually iron out the majority of the tractor troubles is the getting of the farmer educated, not only to handle his tractor correctly, but to be able to see his troubles coming and to know when he is abusing his machine, to know when he is overloading it, to know how to load it properly and all the details of the proper oiling; and then to be able, when some little thing does go wrong, to take care of it in a satisfactory way instead of, for some ridiculous excuse, sending in a call for a service man to come clear across the territory at a great expense to the branch or the factory.

I believe that the keynote is education and the cooperation of the manufacturers as far as possible in getting their men out to help the tractor. When these men educate him, the owner will soon solve the service question. In that way all machines can give a much more satisfactory account of themselves and keep going in a way that they should go.

GEORGE A. ROUND:—In Massachusetts an educational campaign was conducted under a State bureau, and lecturers were supplied from universities and from different firms to educate the farmer in the use of farm machinery. Now they are beginning to use the tractor. The tractor manufacturers had to use kerosene much more quickly than the people in the middle West because our prices for gasoline are higher. We are paying in Boston thirty cents for gasoline and about twelve for kerosene.

ATTENDANCE AT S.A.E. TRACTOR MEETING

MEMBERS

ANDREWS, GEO. C., Andrews Tractor Co., *Minneapolis.*
RANNINGER, J. H., Gurney Ball Bearing Co., *Jamestown, N. Y.*
BARNES, CLAIRE L., Barnes Foundry & Mfg. Co., *Detroit.*
BARTHEL, OLIVER E., 302 Moffat Bldg., *Detroit.*
BATE, JOHN W., Mitchell Motors Co., *Racine, Wis.*
BATEMAN, J. R., Hyatt Roller Bearing Co., *Chicago.*
BEECROFT, DAVID, Class Journal Co., *New York.*
BELL, J. T. R., Gurney Ball Bearing Co., *Jamestown, N. Y.*
BELL, NORMAN, Norma Co. of America, *New York.*
BENNETT, A. C., Wilcox-Bennett Carbureter Co., *Minneapolis.*
BENNETT, R. A., Bennett Auto Supply Co., *Sioux City, Iowa.*
BRISCOE, F., Briscoe Motor Corp., *Jackson, Mich.*
BUCKWALTER, T. V., Timken Roller Bearing Co., *Canton, Ohio.*
BUFFINGTON, H. C., Minneapolis Steel & Machinery Co., *Minneapolis.*
BURT, C. R., Russell Motor Car Co., *Toronto, Ont., Can.*
CARPENTER, GEO. D., C. L. Best Gas Tractor Co., *Dayton, Ohio.*
CHAMPION, A., Champion Ignition Co., *Flint, Mich.*
CHANDLER, M. E., Stromberg Motor Devices Co., *Chicago.*
CHAPIN, ROY D., Hudson Motor Car Co., *Detroit.*
CHRISTOPHER, G. A., Eclipse Machine Co., *Elmira, N. Y.*
CLARKSON, COKER F., S. A. E., *New York.*
CLAYDEN, A. L., Class Journal Co., *New York.*
COFFIN, HOWARD E., Hudson Motor Car Co., *Detroit.*
COX, CLAUDE E., Commercial Engineering Laboratories, *Detroit.*
DABNEY, HOWARD D., S. A. E., *New York.*
DAIN, JOS., JR., Deere & Co., *Moline, Ill.*
DAVIES, D. P., J. I. Case T. M. Co., *Racine, Wis.*
DIEFENDORF, H. G., Gray Motor Co., *Detroit.*
DIXON, EDWARD, Ebert-Duryea Farm Tractor Co., *Chicago.*
DUNHAM, G. W., 868 Woodward Ave., *Detroit.*
DUNTLEY, L. B., Emerson-Brantingham Co., *Minneapolis.*
DUSINBERRE, S. B., New Departure Mfg. Co., *Detroit.*
EASON, C. M., Hyatt Roller Bearing Co., *Chicago.*
EMMONS, E. D., Hayes Mfg. Co., *Detroit.*
FOOTE, J. B., Foote Bros. Gear & Machine Co., *Chicago.*
FRANCIS, J. R., Marvel Carburetor Co., *Flint, Mich.*
FROST, A. H., Van Blerck Motor Co., *Monroe, Mich.*
FRUDDEN, C. E., Parrett Tractor Co., *Chicago Heights, Ill.*
GALLIMORE K. F., Van Blerck Motor Co., *Monroe, Mich.*
GARDNER, H. S., Willard Storage Battery Co., *Chicago.*
GEMLO, JAS., Toro Motor Co., *St. Paul, Minn.*
GLOETZNER, A. A., Covert Gear Co., Inc., *Lockport, N. Y.*
GOODFELLOW, A. N., Standard Roller Bearing Co., *Philadelphia.*
GOULD, E. P., Sumter Electrical Co., *Chicago.*
GREEN, HEATLEY Detroit Gear & Mach. Co., *Detroit.*
GREER, E. P., Emerson-Brantingham Co., *Minneapolis.*
GRIFFITH, H. W., Remy Electric Co., *Detroit.*
GURNETT, C. H., Class Journal Co., *Chicago.*
HALBLEIB, J. C., North East Electric Co., *Rochester, N. Y.*
HANKS, M. W., S. A. E., *New York.*
HARRISON, O. L., Dayton Engineering Laboratories, *Dayton, Ohio.*
HATCH, D. S., Class Journal Co., *Chicago.*
HEASLET, J. G., Studebaker Corp., *Detroit.*
HENDRICKSON, R. O., Wallis Tractor Co., *Racine, Wis.*
HETZEL, FREDERIC V., Link-Belt Co., *Indianapolis.*
HUBER EMIL, Hudson Motor Car Co., *Detroit.*
HUGHES, F. G., New Departure Mfg. Co., *Bristol, Conn.*
JARDINE, ROBT., Rich Tool Co., *Chicago.*
JOHNSON, H. S., Westinghouse E. & M. Co., *Pittsburgh, Pa.*
KAISER, W. L., Sumter Electrical Co., *Chicago.*
KEIM, L. H., R. D. Nuttall Co., *Chicago.*
KETTERING, C. F., Dayton Engineering Laboratories, *Dayton, Ohio.*
KEYS, WALTER C., Standard Parts Co., *Cleveland.*
KING, H. O., Maxfer Truck & Tractor Co., *Chicago.*
KOETHER, B. G., Hyatt Roller Bearing Co., *Detroit.*
KONONOFF, B. A., All Russian Zemstvos & Cities Union, *New York.*
KRATSCH, CHAS., Sumter Electrical Co., *Chicago.*
KRIEG, A., Emerson-Brantingham Co., *Minneapolis.*
MCCORMICK, ELMER, Deere & Co., *Moline, Ill.*
MCINTYRE, M. M., Standard Parts Co., *Cleveland.*
MCVICKER, W. J., McVicker Engineering Co., *Minneapolis.*
MABLEY, C. R., S. K. F. Ball Bearing Co., *Hartford, Conn.*
MANNING, F. C., Sumter Electrical Co., *Chicago.*
MARIEN, CHAS. A., One-Wheel Truck Co., *St. Louis, Mo.*
MASON, CARL T., Splitdorf Electrical Co., *Newark, N. J.*
MILLER, S. G., The Beltrail Tractor Co., *St. Paul, Minn.*
MODINE, A. B., Modine Mfg. Co., *Racine, Wis.*
MOLONY, DON P., Marvel Carburetor Co., *Flint, Mich.*
MOORE, D. K., Standard Parts Co., *Cleveland.*
MOTT, C. S., Weston-Mott Co., *Flint, Mich.*
NILSON, HAROLD, Nilson Tractor Co., *Minneapolis.*
NILSON, LEONARD, Nilson Tractor Co., *Minneapolis.*
NILSON, NILS, Nilson Tractor Co., *Minneapolis.*
OIYEN, ERLING, Standard Steel Car Co., *Coraopolis, Pa.*
OLNEY, RAYMOND, Power Farming, *St. Joseph, Mich.*
O'NEILL, J. J., Laminated Shim Co., *Detroit.*
ORNBERG, IVAN, HUPP Motor Car Corp., *Detroit.*
OZIAS, G. M., Interstate Engine & Tractor Co., *Waterloo, Iowa.*
PARRETT, DENT, Parrett Tractor Co., *Chicago.*
PATITZ, J. F. MAX, Allis Chalmers Mfg. Co., *Milwaukee, Wis.*
PECK, T. A., Vacuum Oil Co., *Rochester, N. Y.*
PLIMPTON, RAYMOND E., S. A. E., *New York.*
POSTLETHWAITE, P. B., Wagner Electrical Mfg. Co., *St. Louis, Mo.*
REPLOGLE, J. B., Remy Electric Co., *Detroit.*
RICHARDS, J. H., Bijur Motor Lighting Co., *Hoboken, N. J.*
RODGERS, FRANK A., Jr., The Sparks Withington Co., *Jackson, Mich.*
ROOT, F. C., General Aluminum & Brass Mfg. Co., *Detroit.*
ROSE, P. S., Clarke Publishing Co., *Madison, Wis.*
ROUND, G. A., Vacuum Oil Co., *Boston, Mass.*
ROYER, A. H., McVicker Engineering Co., *Minneapolis.*
RUSSELL, THOS. A., Willys-Overland Ltd., *Toronto, Can.*
SARGENT, C. E., Lyons Atlas Co., *Indianapolis.*
SCARRATT, A. W., Minneapolis Steel & Machinery Co., *Minneapolis.*
SCHEFFERLY, ROBT. J., Wichita Falls Motor Co., *Wichita Falls, Tex.*
SCHRIBER, RUFUS K., H. C. Doman Co., *Oshkosh, Wis.*
SCHWER, G. A., Dauch Mfg. Co., *Sandusky, Ohio.*
SCHWITZER, LOUIS, The Oakes Co., *Indianapolis.*
SEATON, L. F., University of Nebraska, *Lincoln, Nebr.*
SEXTON, F. B., Van Blerck Motor Co., *Monroe, Mich.*
SHAW, I. D., Cincinnati Ball Crank Co., *Detroit.*
SHOOP, R. B., *Minneapolis.*
SILVER, W. H., Deere & Co., *Moline, Ill.*
SLOAN, A. P., Jr., Hyatt Roller Bearing Co., *Newark, N. J.*
SMITH, LON R., The Buda Co., *Harvey, Ill.*
SPICER, C. W., Spicer Mfg. Co., *S. Plainfield, N. J.*
STAHL, R., Briscoe Motor Corp., *Jackson, Mich.*
STEELE, F. P., Lyons-Atlas Co., *Indianapolis.*
STIGER, C. W., Stromberg Motor Devices Co., *Chicago.*
STONE, G. B., Remy Electric Co., *Anderson, Ind.*
STRATFORD, C. W. Platt & Washburn Refining Co., *New York.*
STRITE, G. T., *Minneapolis.*
SUNDERMAN, F. R., Sunderman Corp., *Detroit.*
SWANDER, DAN C., Standard Parts Co. *Cleveland.*
SWINTON, D. R., Standard Parts Co., *Cleveland.*
SZEKELY, OTTO, Velie Motors Corp., *Moline, Ill.*
TAYLOR, R. H., Zenith Carbureter Co., *Chicago.*
TEAGLE, F. H., The Teagle Co., *Cleveland.*
THOMAS, T. R., Thomas & Thomas, *Detroit.*
TIPPER, HARRY, Class Journal Co., *New York.*
URSCHEL, B. H., Universal Machine Co., *Bowling Green, Ohio.*
VAN BLERCK, JOS., Van Blerck Motor Co., *Monroe, Mich.*
VAN DEVENTER, H. R., Splitdorf Elec. Co., *Sumter, S. C.*
WALSH, C. C., S. K. F. Ball Bearing Co., *Hartford, Conn.*
WALTER, F. B., Service Motor Truck Co., *Wabash, Ind.*
WALTER, FRED B., Service Motor Co., *Wabash, Ind.*
WEISS, JAY G., Hyatt Roller Bearing Co., *Newark, N. J.*
WHITNEY, CHAS. S., Willard Storage Battery Co., *Chicago.*
WILDER, G. E., Gemmer Mfg. Co., *Detroit.*
WINTER, E. A., Falls Machine Co., *Sheboygan Falls, Wis.*
WORTHINGTON, WAYNE H., Electric Wheel Co., *Quincy, Ill.*
YOUNG, O. W., Hyatt Roller Bearing Co., *Minneapolis.*
YOUNGER, JOHN, Pierce-Arrow Motor Car Co., *Buffalo.*
ZIMMERMAN, J. G., Sumter Electrical Co., *Chicago.*

GUESTS AT S. A. E. TRACTOR MEETING

*ADAMS, H. J., Garford Motor Truck Co., *Lima, Ohio.*
AHART, J. LEO, J. I. Case T. M. Co., *Dow City, Iowa.*
ALEXANDER, C. K., Wheeler-Schebler Carbureter Co., *Indianapolis.*
ALLEN, CHARLES J., S. L. Allen & Co., *Philadelphia.*
ALLEN, HERBERT D., Chilton Co., *Philadelphia.*
*ARMBRUST, C. R., H. J. Walker Co., *Cleveland.*
ARMSTRONG, J. H., Cutting-Armstrong & Smith, *Detroit.*
AUSTIN, L. A., Rutenber Motor Co., *Marion, Ind.*
BAILEY, J. M., *Yukon, Okla.*
BAKER, B. G., Smith Form-A-Truck Co., *New York.*
BAKER, GEO. J., 122 Theodore St., *Detroit.*
BAKER, H. B.
BAKER, M. M.
BALDIN, S., Gen., Russian Commission, *New York.*
BALLENTINE, R. W.
BARTLETT, G. M., Diamond Chain Mfg. Co., *Indianapolis.*
BATTEN, P. H.
BECKWITH, C. A.
BELL, THOS., Dauch Mfg. Co., *Sandusky, Ohio.*
BERRYHILL, J. H., Vulcan Plow Co., *Evansville, Ind.*
BILL, L. H., Fageol Motors Co., *Oakland, Cal.*
*BOHAN, T. J., Gurney Ball Bearing Co., *Cuicago.*
BORING, C. E.
BRINKBAUER, P. P., Dauch Mfg. Co., *Sandusky, Ohio.*
BRISCOE, BENJAMIN.
BROWN, GUY C., Campbell Ewald Co., *Detroit.*
BUDERUS, W. H., Vacuum Oil Co., *Chicago.*
BULLOCK, G.
BURCH, D. S., Crowell Publishing Co., *New York.*
BURNS, L. N., J. I. Case Plow Works *Racine, Wis.*
BURNS, W. T., Timken Roller Bearing Co., *Canton, Ohio.*
CALKINS, A. N., Electric Wheel Co *Quincy, Ill.*
CAMERON, W. W., La Crosse Plow Co., *La Crosse, Wis.*
CARMODY, J. D., Champion Spark Plug Co. *Toledo, Ohio.*
CARVER, W. L., Moline Plow Co., *Moline, Ill.*
CASTINO, S. K. F. Ball Bearing Co., *Chicago.*
CHANDLER, F. F.
CHOWN, H. W.
CHRISTENSON, FRED.
CLARK, C. C.
CLARK, H. J., *Port Huron, Mich.*
CLARK, W. G., Wilcox-Bennett Carbureter Co., *Minneapolis.*
COLEMAN, J. A., Madison-Kipp Lubricator Co., *Madison, Wis.*
COOPER, HOWARD, Texas Co. *New York.*
COSTELLO, M. F. P., Iowa State College, *Ames, Iowa.*
CRANDELL, H. F., J. I. Case T. M. Co., *Racine, Wis.*
CRAVATH, L. B.
CRAWFORD, A R.
CRAWFORD, R. P., Horseless Age, *Lincoln, Nebr.*
CURRIE, B. W., Country Gentleman, *Philadelphia.*
DAUCH, J. J., Dauch Mfg. Co., *Sandusky, Ohio.*
DAVENPORT, R. G
DAVIDSON, E. C., Power Farming, *St. Joseph, Mich.*

* *Applications received.*

DEAN, F. A.
*DELORME, A. C., Splitdorf Elec. Co., *Chicago.*
*DE MARINGE, A., U. S. Ball Bearing Mfg. Co., *Chicago.*
DENNING, J. M., Denning Tractor Co., *Cedar Rapids, Iowa.*
DEMING, ROBERT.
DICKSON, C. P., Prairie Farmer, *Chicago.*
DIXON, C. B.
DODSLEY, A. D.
DODSON, VICTOR, Nilson Tractor Co., *Minneapolis.*
DONOVAN, E. J.
*DRAY, W. R., Hart-Parr Co., *Charles City, Iowa.*
DRUM, E. C., Elgin Tractor Corp., *Elgin, Ill.*
DUKES, W. J., Vacuum Oil Co., *Chicago.*
DUPONT, R., Climax Engineering Co., *Clinton, Iowa.*

EDENS, H. N.
EDWARDS, W. J.
ELY, HEMAN, Timken Roller Bearing Co., *Canton, Ohio.*
ERICKSON, A.
*EVANS, R. T., Evans Mfg. Co., *Hudson, Ohio.*
EVERETT, H. E., Implement & Tractor Trade Journal, *Kansas City, Mo.*
EWALD, HENRY, Campbell Ewald Co., *Detroit.*

FAIRMAN, H. E.
FARRIS, R. B.
FLOOD, JAMES A.
FLOOD, J. D., Modine Mfg. Co., *Racine, Wis.*
FORNIER, C. B.
FRIEBERG, O. B.
FROCKINS, E. A.

GARDNER, C. R.
*GEYER, E. H., Kokomo Electric Co., *Kokomo, Ind.*
GILLESPIE, H. A., S. K. F. Ball Bearing Co., *Hartford, Conn.*
GILLMAN, F. L., Western Electric Co., *New York.*
GITHERS, E. J., J. I. Case T. M. Co., *Racine, Wis.*
*GLASS, F. E., Oakes Co., *Indianapolis.*
GRAHAM, J. B., The De Vry Corp., *Chicago.*
GRAY, R. T., Shuman Advertising Co., *Chicago.*
GREEN, R. H.
GREENBERG, A. A., The Farmer, *St. Paul, Minn.*
*GREENWOOD, H. V., Baldwin Chain & Mfg. Co., *Worcester, Mass.*
GROSS, E. R., Colorado Agricultural College, *Ft. Collins, Colo.*
GROTEN, MAXIMILIAN, Woolworth Bldg., *New York.*

HALL, GUY.
HALL, L. G.
HALTENBENGER, JULES, Briscoe Motor Corp., *Jackson, Mich.*
HAMEAU, Mr.
HAMILTON, RUSH, Fageol Tractor Co., *Oakland, Cal.*
HAND, FRED, Vulcan Plow Co., *Evansville, Ind.*
HENNAND, MATT, *Clinton, Iowa.*
HARRELL, C. E., Acheson Graphite Co., *Niagara Falls, N. Y.*
HAWLEY, D., Wilcox-Bennett Carbureter Co., *Minneapolis.*
HIGGEM, CHAS. O., The Russell Co., *Massillon, Ohio.*
HICKS, C. E., Dauch Mfg. Co., *Sundusky, Ohio.*
HINDELANG, T. E., J. I. Case Plow Works, *Racine, Wis.*
HOBART, F. G., Fairbanks, Morse & Co., *Beloit, Wis.*
HOLCOMB, D. V., John Lausen Mfg. Co., *New Holstein, Wis.*
HOLL, J. S., Link-Belt Co., *Indianapolis.*
HOLT, H. W., Aluminum Castings Co., *Detroit.*
*HOLT, P. E., The Holt Mfg. Co., *Stockton, Cal.*
HOMS, JUAN, U. S. Dept. of Commerce, *Washington, D. C.*
HOUSE, C. M.
HURLBURT, JOHN, L. M. H. Development Co., *Detroit.*
HURLEY, S. C., Diamond Chain Mfg. Co., *Indianapolis.*
HUSHHEMER, H. W., La Crosse Plow Co., *La Crosse, Wis.*
HYATT, J. C., Crowell Publishing Co., *New York.*

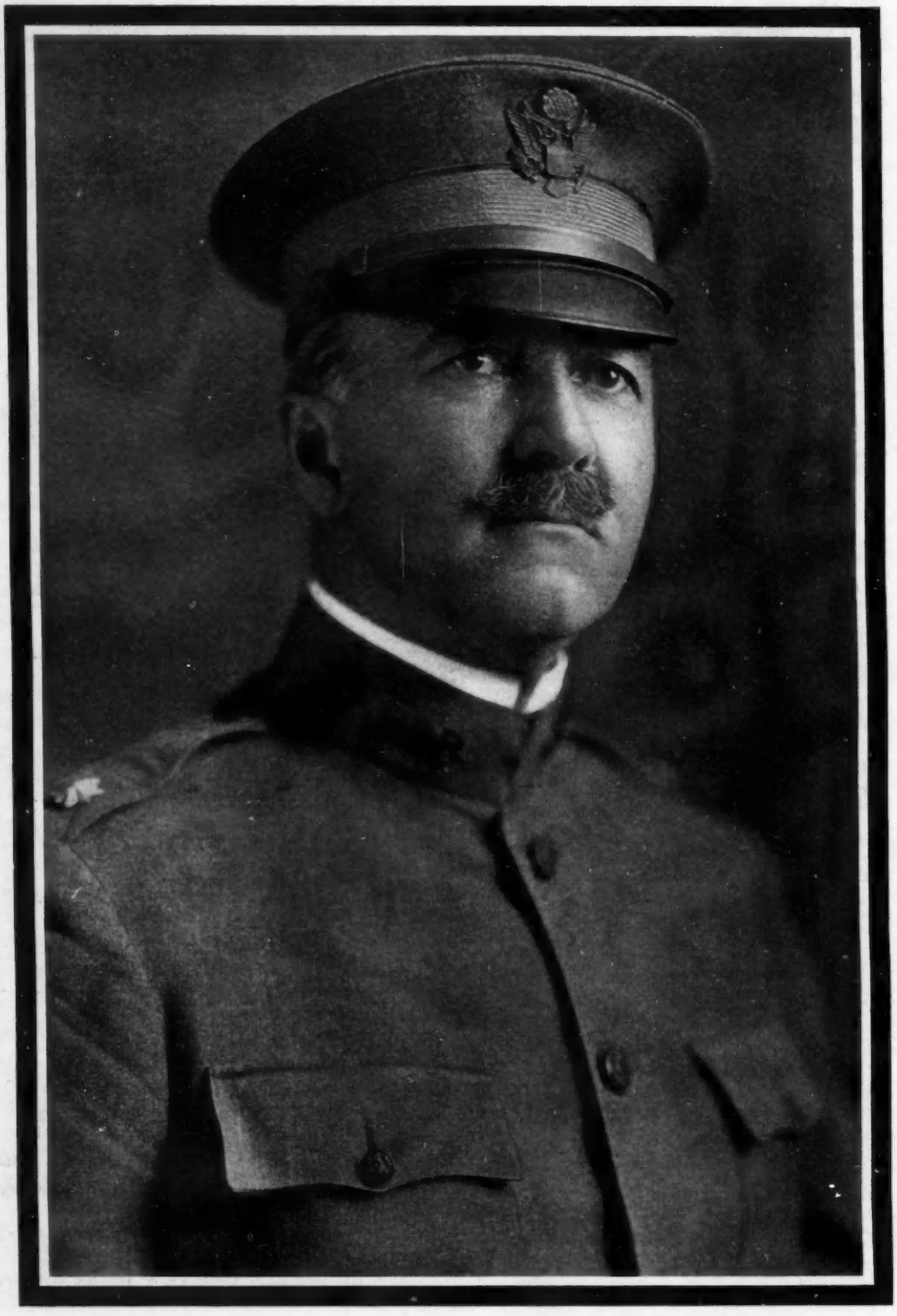
JACK, E. L.
JACKSON, P. E., Standard Roller Bearing Co., *Philadelphia.*
JAYNES, FRANK E., Dayton Bros.
*JENKINS, ELBERT J., Four-Wheel Drive Tractor Co., *Big Rapids, Mich.*
JESSON, JAMES, Line-Drive Tractor Co., *St. Louis, Mo.*
JOHNSON, CHAS., Maltby Specialty Co. *Detroit.*
JOHNSON, J. R., La Crosse Plow Co., *La Crosse, Wis.*
JOHNSTON, E. A., International Harvester Corp, *Chicago.*
JONES, J. E., C. L. Best Gas Tractor Co., *San Leandro, Cal.*
JULSRUD, Nilson Tractor Co., *Minneapolis.*

KAPOUSTIN, T. N., Russian Commission, *New York.*
KEENE, C. F., Ensign Carbureter Co., *Los Angeles, Cal.*
KEITH, R. P.
KENNEDY, B. A.
KERR, MARK M., Wolverine Tractor Co., *Detroit.*
KERR, ROBT.
KIEFFER, NICK, *Fedora, S. D.*
KILLEAN, J. L., Climax Engineering Co., *Clinton, Iowa.*
KLINEDINST, L. M., Timken Roller Bearing Co., *Canton, Ohio.*
KLOPPE, J.
KOODRJAVTSHEFF, M. V., Russian Commission, *New York.*
KOTCHETKOV, W. P., Russian Commission, *New York.*
KRAUS, G. A., Champion Spark Plug Co., *Toledo, Ohio.*
KROHN, W.
KUECHENMISTER, H. O., Roller Bearing Co.

*LAONI, A. M., *Dayton, Ohio.*
LARSEN, C. M., The Texas Co., *New York.*
LASTOVETZ, Mr., Russian Commission, *New York.*
LAUSON, H. D., John Lauson Mfg. Co., *New Holstein, Wis.*
LEE, FRED G., Class Journal Co., *Chicago.*
LEIST, H. FORREST.
LEVING, E. J.
*LINDSLEY, H. T., Bound Brook Oil-less Bearing Co., *Detroit.*
LINK, J. A., Dauch Mfg. Co., *Sandusky, Ohio.*
LONG, J. C., S. K. F. Ball Bearing Co, *Hartford, Conn.*
LOVEDAY, G. R.

MCCULLOUGH, E. W., National Implement and Vehicle Mfg. Assn., *Chicago.*
MCLAUGHLIN, T. B., Splitdorf Elec. Co., *Chicago, Ill.*
MCNEFIN, T. J., Nelson Tractor Co., *Lewistown, Mont.*
MAAS, FRANK W., Power Farming, *St. Joseph, Mich.*
MACGREGOR, W. F., J. I. Case T. M. Co., *Chicago.*
MACVICKER, W. J.
MAGUIRE, JAS. S.
MAHONEY, J. B.
MARSCHNER, F. W., New Departure Mfg. Co., *Detroit.*
MARTIN, F. B., Nilson Tractor Co., *Minneapolis.*
MARTIN, J. E.
MATSON, G. M., John Lauson Mfg. Co., *New Holstein, Wis.*
MEARS, B. B.
MEGOW, C. F., Convertible Tractor Corp., *St. Paul, Minn.*
MEREDITH, P. C., Meredith Motor Car Co., *Des Moines, Ia.*
MERRITT, H. C., Hart-Parr Co., *Charles City, Iowa.*
MESSINGER, W., Standard Roller Bearing Co., *Philadelphia.*
METZ, ALBERT G., Chilton Co., *Philadelphia.*
MEYERS, F. O., Dauch Mfg. Co., *Sandusky, Ohio.*
MICHAEL, C., J. I. Case Plow Works, *Racine, Wis.*
MONTFORT, G. S., Dyneto Electric Corp., *Syracuse, N. Y.*
MOREE, K. E.
MONTFORD, G. S.
MYLAND, D. W.
MYERS, F. O.
NAIRN, A. K., Gurney Ball Bearing Co., *Jamestown, N. Y.*
NASH, CHAS. W., Nash Motors Co., *Kenosha, Wis.*
NEWMAN, L. I.
NISS, CLARENCE C., Line Drive Tractor Co., *Milwaukee, Wis.*
NORELIUS, E. F., Holt Mfg. Co., *Stockton, Cal.*
OSESIS, Mr.
OVERTON, GLENN.
OZIAS, BLAKE.
PARKER, J. B.
PARKER, O. C., Dauch Mfg. Co., *Sandusky, Ohio.*
PARKS, M. G., Vesta Accumulator Co., *Chicago.*
PARRETT, B. R., One-Wheel Truck Co., *St. Louis, Mo.*
PARRETT, H. T., Parrett Tractor Co., *Chicago.*
PENN, C. A.
PERKINS, C. F., Modine Mfg. Co., *Racine, Wis.*
PETERSON, W. H., Minneapolis Steel & Mach. Co., *Minneapolis.*
PETTIT, B. M., J. I. Case Plow Works, *Racine, Wis.*
PETTIT, F. R., J. I. Case Plow Works, *Racine, Wis.*
PETTIT, M. H., J. I. Case T. M. Co, *Racine, Wis.*
POWER, G. G., General Aluminum & Brass Mfg. Co., *Detroit.*
PUTNAM, W. H., Madison-Kipp Lubricator Co., *Madison, Wis.*
RAGAN, F. H., Gemmer Mfg. Co., *Detroit.*
REID, H. F., Raybestos Co., *Bridgeport, Conn.*
REINKEN, E. E.
RILEY, Prof. H. W.
RINDERLE, O. F., Dauch Mfg. Co., *Sandusky, Ohio.*
ROBINSON, F. J., Class Journal Co., *Chicago.*
ROCKE, FRANK, Automobile Topics, *New York.*
ROCKE, PAUL L., Automobile Topics, *New York.*
ROGERS, J. C.
ROHIS, GEORGE C.
RORABECK, C., C. L. Best Gas Tractor Co., *San Leandro, Cal.*
ROSENCRANZ, Mr.
RUSSELL, C. E., J. I. Case T. M. Co., *Racine, Wis.*
RUSSELL, E. E.
RYDER, F. J., S. K. F. Ball Bearing Co., *Hartford, Conn.*
RUCK, ED.
SACKMAN, J. O.
SCHIBSBY, M., J. I. Case Plow Works, *Racine, Wis.*
SEELEY, F. E.
SENCEBAUGH, C. K., Vacuum Oil Co., *Chicago.*
SETZ, H. R.
SEWELL, H. F., Dollenmayer Advertising Agency, *Minneapolis.*
SHAFFER, CLEVE T., Fageol Tractor Co., *San Francisco, Cal.*
SKELTON, F. L., Parrett Tractor Co., *Chicago.*
SLASTENIN, Mr., Russian Commission, *New York.*
SMITH, ASA.
SMITH, C. H.
SMITH, H. P.
SMITH, J. HENRY, Rich Tool Co., *Chicago.*
SOLOMON, E. J., Avery Co., *Peoria, Ill.*
*SPAULDING, F. J., Link-Belt Co., *Chicago.*
SPICER, H. W., Spicer Mfg. Co., *S. Plainfield, N. J.*
SPIRO, J. D.
SPRINGER, W. M.
STADELMAN, FREDERIC, Wellman-Seaver-Morgan Co., *New York.*
STEBBINS, C. B., Climax Engineering Co., *Clinton, Iowa.*
STOCKFISH, JOHN M., Platt and Washburn Refining Co., *Chicago.*
*SWEENEY, E. J., Sweeney Automobile School Co., *Kansas City, Mo.*
TAFF, F. N., Duane H. Nash, *Millington, N. J.*
TAYLOR, W. H.
THOMPSON, J. A., Smith Motor Truck Corp., *Chicago.*
*THOMPSON, H. L., Moline Plow Co., *Moline, Ill.*
TOWNSEND, W. A.
TRENT, L. E., Common Sense Tractor Co., *Minneapolis.*
TURKENKOPF, S. C., Moline Plow Co., *Moline, Ill.*
TURNBULL, W.
VON VOLKENBURG, L. R., Avery Co., *Peoria, Ill.*
WADE, J. H., La Crosse Plow Co., *La Crosse, Wis.*
WAITE, H. C., Elgin Tractor Corp., *Elgin, Ill.*
WALKER, A. B., Geuder, Paeschke & Frey Co., *Milwaukee, Wis.*
WALLACE, L. T., Campbell Ewald Co., *Detroit.*
WALLIS, H. M., Jr., Wallis Tractor Co., *Racine, Wis.*
WARNER, D. L.
WATSON, E. G.
WELLES, H. O., Detroit Gear & Machine Co., *Detroit.*
WELLMAN, FRED, Wolverine Tractor Co., *Detroit.*
WEST, W. V., Power Farming, *St. Joseph, Mich.*
WEYLAND, GROVER, J. I. Case Plow Works, *Racine, Wis.*
WHITE, GEO. A., Sparks-Withington Co., *Jackson, Mich.*
WHITE, W., La Crosse Plow Co., *La Crosse, Wis.*
WHITNEY, A. B., Ohio Mfg. Co.
WHYTE, JOHN, Bailey Non-Stall Differential Corp., *Chicago.*
WIGGINS, E. R., Deere & Co., *Moline, Ill.*
WIGLEY, R. B.
WILDS, JOS. B.
WILLIAMS, A.
WILLIAMS, L. B., Dayton Elect. Lab. Co., *Dayton, Ohio.*
WILLIAMSON, F. B., Sumter Electrical Co., *Chicago.*
WILSON, F. H., B. F. Avery & Sons, *Louisville, Ky.*
WOODS, E. L., J. I. Case Plow Works, *Racine, Wis.*
WORBOIS, H L.
WORLEY, H. F., Nelson Tractor Co., *Kansas City, Mo.*
ZOLLINGER, FRANK, Timken Detroit Axle Co., *Detroit.*

* *Application received.*



MAJOR HENRY SOUTHER, U. S. R.

A Pioneer in Standardization

By General Manager Coker F. Clarkson

IN the passing of Major Henry Souther, U. S. R., senior officer of the Aircraft Engineering Division of the United States Army Air Service, the Society, the Government and the country have sustained a great loss.

Major Souther served as President of the Society during 1911 and was the first chairman of its Standards Committee, his term of office continuing from 1910 to 1915. In the latter year he was made a life member of the Society because of his work for standardization.

The Society had no better friend than Henry Souther. His work in the standardization of materials and in connection with parts was of vital importance in the automotive industry and stands as a monument to him. He was the exponent of standardization to the *n*th power.

This outstanding man was in many views the originator of the plan to inaugurate intimate cooperative meetings of automobile engineers and was conspicuously identified with the remarkable pioneer activities of the Mechanical Branch of the Association of Licensed Automobile Manufacturers.

For many years he gave surprisingly close attention to details of the complex questions involved in the studies and meetings of the numerous divisions of the Standards Committee; from the beginning of the Society's standardizing work, after the Society had become the custodian of the mechanical standards of the Association of Licensed Automobile Manufacturers, to the time when the arduous duties of an executive position he had accepted prevented his giving the Society Committee work the attention he in conscience felt it demanded. He set a shining example for the successors to the honorary position of chairmanship of the Standards Committee. He established the work on such firm foundations, conducted it so wisely, and extended its scope to such an extent as to make the later great success of the S. A. E. Standards Committee possible. His policy was essentially one of driving ahead with the one thought of advancing the industry in a sound, commercial way by simplifying and coordinating vexatious questions involved in the design and production of mechanically propelled vehicles, by bringing to a standard many diversified questions of materials and parts which, for the good of all, speaking in general terms, should be solved in a concordant or identical manner, that the industry and the users should not have to bear the burden of the astonishingly great number of immaterial differences of specifications and dimensions of materials and parts.

Henry Souther was a big man. He held securely the admiration and affection of the members of the Society. Distinctively fair-minded, he brought his remarkable judicial temperament to bear in straightforward fashion.

Major Souther was born in 1865 at Boston. After graduating from the Massachusetts Institute of Technology and taking post-graduate work at the leading metallurgical schools of Germany, he was employed at the works of the Pennsylvania Steel Company, Steelton, Pa. Later he was identified closely with large bicycle production in metallurgical and general consulting capacities. He brought from this field to the automobile industry much valuable engineering data, including the results of tests of pneumatic tires of the fabric and of the cord types. He was for some time State Chemist of Connecticut. He conducted for many years at Hartford a chemical and physical testing laboratory. This laboratory was used in much pioneer automobile engineering work by the Mechanical Branch of the A. L. A. M., with Mr. Souther in charge as advising engineer to a committee of automobile specialists of high reputation. Tests and analysis were made of all representative foreign and domestic steels and of many other metals, including aluminum and bearing materials. The first of the White-Souther alternate stress testing machines was installed in this laboratory. Chemical and physical tests of pneumatic tires were made; methods for determining the amount of piston-ring friction in cylinders were devised.

Elaborate tests of internal-combustion engines of the automobile type were conducted. An exhaustive series of inlet valve closing researches was made, involving the first use in this country of such instruments as the Mathot indicator and the Carpentier-Hospitalier manograph, and establishing many features upon which modern automobile engine testing is based. An electric dynamometer of the cradle type was installed in 1906. It was this work which, in connection with the monthly meetings of the engineers of the A. L. A. M. Mechanical Branch, put the American Automobile on its feet in world competition. Not only was the vital lesson of cooperation learned, but the volume of advance data was such as to forward the design and production of reliable and satisfactory automobiles in large quantity, the quantities increasing each year beyond the bounds of imagination. The new devices apparently deserving attention were studied, and information regarding them disseminated, as well as clear and forceful descriptions and statements of worthy practices which had been tried to a material extent.

The standardization idea crystallized into concrete achievement at this time, the A. L. A. M., now S. A. E., screw standard being established in 1906. The so-called Autocar spark-plug standard, which has survived in the form of the present 7/8-18 S. A. E. Standard Spark-plug Shell, had, however, received recognition prior to this time.

At the time the S. A. E. entered the beginning of the phase of its present activities, in 1910, Major Souther had been continuing his consulting practice, having commitments from various automobile manufacturing and transportation companies. He then became associated with the Standard Roller Bearing Company and made an extensive investigation of wire-wheel construction. In 1914 he was made general manager of the Ferro Machine & Foundry Company of Cleveland.

At the outbreak of the great war, Major Souther became deeply interested in the movements in this country looking toward real preparedness. Early in 1916 he assumed duties with the Government, making in his usual whole-hearted way intensive investigations in the airplane field, with regard particularly to engines. He reentered the service of the Society actively, becoming the first chairman of the Aeronautic Division of the Standards Committee, in which capacity he served until his position with the Government interfered with regular at-

tendance at committee meetings. As director of the Aeronautic Division he made very commendable headway, getting the work started on effective lines after thorough consideration of the many new problems involved. He presided at the first aeronautic session of the Society in February, 1917, and presented an able address on the needs for and the possibilities of standardization work. This address was followed by an illuminating discussion which has in large part formed the basis of the present proceedings of the Aeronautic Division.

In the Government service, Major Souther built well and wisely for the development of the United States Air Service, which is of such fundamental and vital importance to the cause of the Allies. He had recently been put in charge of Langley Field at Hampton, Va., this detail including the conduct of the experimental work on engines. He was to have been promoted to a lieutenant-colonelcy.

Major Souther died at Fortress Monroe Hospital on Aug. 15, not surviving an operation resulting from an acute development of a recurrent malady of an indigestional nature. It is believed that the assiduity with which he applied himself in the Government service resulted in an overtax of his physical strength.

Major Souther's work while for the past year associated with the Aviation Section of the Signal Corps, first as consulting engineer, and later as major, United States Officers' Reserve Corps, was fundamental in character. From the very outset his foresight and imagination led to a conception of the vastness of the problem and to the evolution of an organization to cope with the work.

The activities at Langley Field, where design, experimentation and research in connection with aircraft development will be carried on, are to a great degree the result of Major Souther's grasp of the problems.

The multitude of specifications and other details whereon are founded production work now under way were largely the result of Major Souther's activities.

In the various Divisions and Departments of the Signal Corps which have now delegated to them the onerous burden of meeting the immense production program laid down, will be found many features initiated by Major Souther, upon which are built the structures of the present Signal Corps Air Service organization.

Major Souther will not be identified in the public eye with the aircraft production program which must be brought to a successful conclusion. It will, however, remain for his associates always to remember that the breadth and solidity of the foundation for the completion of this great problem, were in large measure due to the keen mind, tireless application, and that quality which attracts loyal support, which were but a few of the admirable characteristics of Major Henry Souther.

The records of the Society bear testimony to Major Souther's grasp of the philosophy underlying engineering standardization. Many of his expositions of the problem seem even more apt today, in view of the broader standardization work in progress, than when they were first propounded. The following paragraphs, selected from his addresses, are in themselves a wonderful tribute to Major Souther:

"There is the class which believes that a standard, in order to be worth anything at all, must not be adopted or recommended until everything is known about its subject. In contrast, there is the class which seems to believe that almost anything can be standardized, and which would go to very great extremes in the matter. One group believes that standardization should begin early in the history of an industry, the other believes that no standard is possible in an industry until it is so old that probable changes in proposed standards are few and far between. Some believe that if a standard is not everlasting it should not be designated 'standard'; others that a standard is subject to change at any time. It is the belief of the S. A. E. Standards Committee that standards should be accepted as rapidly as possible and should be kept up to date by following the art closely and making such changes as may be necessary from time to time. Portions of a construction can properly be standardized at a given time and other details must await further developments. It is most desirable to have the few agreed points standardized rather than do nothing.

The Committee realizes perfectly well that too many standards, or ill-considered standards, are worse than none at all, and that it must not go too fast. But it also realizes that there are certain things that must be standardized to save untold confusion. Standardization is viewed with most favor by those who have gone most deeply into the subject. It is viewed unfavorably by those who do not understand what kind of a standard is aimed at. A standard, in order to be accepted, must have so much merit that engineering or producers or executives will see good reason for its acceptance. Good engineering design may be the reason it is worthy of universal adoption; easy manufacture may be another reason why the business organization would say to the others involved that it must be adopted. As a matter of fact, all three of these qualities will usually be found in any good standard. The adoption of a standard is not compulsory, it is voluntary. The records of the Society are rich with engineering knowledge brought out in connection with the discussion of standards proposed, whether accepted or not.

"One user of broaches has expressed the belief that a standard would not help him much as to cost or ease of manufacture. His belief is based upon the fact that the designer always specifies the detail of the hole to be broached and the broach must be made accordingly. This user of broaches has overlooked the fact that if some standard or recommended practice be adopted, the designer will incorporate it in his product, and the maker of broached holes will then receive a drawing which calls for a standard broach, and thus eliminate the tendency to use special broaches. If the standard recommended be a good one, when once accepted, this and only this can happen. It will be easier for the designer, easier for the draftsman, easier for the manufacturer of the broach and for the manufacturer of the broached holes, and also for the purchaser of the car, because theoretically the car will cost less.

"A draftsman can safely incorporate in the design of gas engines such carbureter flanges and connections as the standards or recommended practice will show. He will be taking no chances and there will be no experiments involved. And the designer need not fear that his engine will be defective because of inferior carbureter connections. Such standards as these ought to endure for many years or until there shall be a radical departure from our present system of carburetion.

"The work of the Iron and Steel Division of the S. A. E. Standards Committee is a continuation of that undertaken by the mechanical representatives of the companies that formed the Association of Licensed Automobile Manufacturers. In 1905 the subject of materials suitable for automobile construction came up for discussion before the meetings of the engineers of the A. L. A. M. Their own experience and practices were discussed, and metallurgists and representatives of the steel companies were heard. These men gave up to date information as to the

progress of the steel-making art; and upon this foundation and its yearly developments the Iron and Steel Division has built its reports. The meetings of the Division have been numerous, and the amount of data threshed out at them is probably in excess of the work done by any similar committee of metallurgists.

"It can be said safely that the S. A. E. Steel Specifications are standard recommendations; the steels are not special steels, and therefore all can be considered standard in their classes, in the sense that they are not freak steels. They are standard articles of commerce, just as silk, wool or cotton are standards in their way. Each has its own particular field of usefulness.

"The work of the Truck Tire Division has been startling in its success. The situation was apparently an impossible one when the Division took up its labors. There were a dozen or more makes of tires and styles of rim, and for every nominal size there was a different actual size. The differences were small but important in the mind of each of the tire manufacturers. The conditions existing in the truck factories was intolerable. It was common for a truck manufacturer to have from five to fifteen trucks standing ready for delivery with the exception of wheels and tires. Special wheels had to be ordered and the order depended absolutely upon the tire specifications. There was no possibility of stocking with either the wood wheels or the tire.

"The user of the motor car is benefited by the efforts of our organization, inasmuch as a better and cheaper car is obtained than would otherwise be possible. The industry as a whole, including stockholders and employees, is benefited; the standardized car reaches more people, because it is both cheap and good. It is not possible to produce a good cheap car made up of parts that are not standardized."

Of the Handbook of the Society, the inception of which was due to Major Souther, he had to say:

"The Data Sheets constitute the most active missionary of our work. The volume of engineering data, discussed and approved by the Society, finds its way onto hundreds of drafting-room tables. The result is that our recommended or standard constructions or practices creep into many new designs. It is easy to use them. The draftsman is saved a great deal of thought that would, otherwise, be given to petty detail. The data given or the sketches shown represent the sober thought of a competent committee, refined by the active criticism of many members. The information given does not represent the whim of some one man.

"The greatest force that can be utilized in lowering the cost of production and improving quality at the same time, lies along the line of standardization of parts."

Thus spoke Henry Souther, one of the greatest protagonists of mechanical standards of all time, and probably, from the viewpoint of practical work and effect, the greatest representative the world has known of the concept that standardization means the elimination of the unnecessary in the engineering sense.

View of Bureau of Standards—South Building in Foreground

The National Bureau of Standards

EDITORIAL CORRESPONDENCE *Illustrated with* CHART AND PHOTOGRAPHS

ONE event scheduled for the recent meeting of the Society in Washington was a trip to the various laboratories of the Bureau of Standards. The pressure of Society activities left little opportunity for the members to make this trip, although all the arrangements had been made and members of the Bureau were in waiting to act as guides. A description of the work being done by the Bureau will probably interest members who could not attend the Washington meeting, as well as those who were present. The work being done by such a national leader in standardization should of course be thoroughly known to the members of the Society of Automotive Engineers, which is one of the greatest organizations of a semi-public nature in the world devoted to engineering standardization.

The Bureau is a successor to the Office of Standard Weights and Measures which formed a part of the Treasury Department for many years. The Bureau was established in 1901 and remained in the Treasury Department until 1903, when the Department of Commerce was instituted, taking over among other activities the work of standardization as carried on by the Bureau.

The act to establish the National Bureau of Standards was approved in 1901. In this act, which is still the organic law on which the Bureau operates, Congress provides:

"That the functions of the Bureau shall consist in the custody of the standards; the comparison of the standards used in scientific investigations, engineering, manufacturing, commerce, and educational institutions with the standards adopted or recognized by the Government; the construction, when necessary, of standards, their multiples and subdivisions; the testing and calibration of standard measuring apparatus; the solution of problems which arise in connection with standards; the determination of physical constants and the properties of materials, when such data are of great importance to scientific or manufacturing interests and are not to be obtained of sufficient accuracy elsewhere.

"That the Bureau shall exercise its functions for the Government of the United States; for any state or municipal government within the United States, or for any scientific society, educational institution, firm, corporation, or individual within the United States engaged in manufacturing or other pursuits requiring the use of standards or standard measuring instruments. All requests for the services of the Bureau shall be made in accordance with the rules and regulations herein established."

These two sections indicate fully the nature of the work the Bureau has to do and also show how the work is to be done. In a later section of the law it is provided that reasonable fees shall be charged for all investigations and other work, except when performed for the Government of the United States or for state governments within the United States. The organic law covers broadly the activities of the Bureau; it has at all times striven to keep abreast and even ahead of the in-

dustries of the country. Its present functions are well set forth in the accompanying tabulation taken from the last annual report of Dr. S. W. Stratton, the director of the Bureau.

The Bureau is exceedingly fortunate in both its location and personnel. The laboratories are located in the northwest section of Washington about six miles out from the Capitol. This location insures freedom from mechanical, electrical and other disturbances common to the business and thickly populated sections of the city. As shown on the accompanying plan, there are now five large buildings in use. A number of smaller buildings are also employed for the various activities of the Bureau. These buildings are well fitted out with the necessary testing machinery and instruments. In spite of this seemingly large equipment the work of the Bureau has increased so rapidly that still more room is needed. The plans have been prepared for several new laboratories, and these will probably be built just as soon as the necessary appropriations are secured.

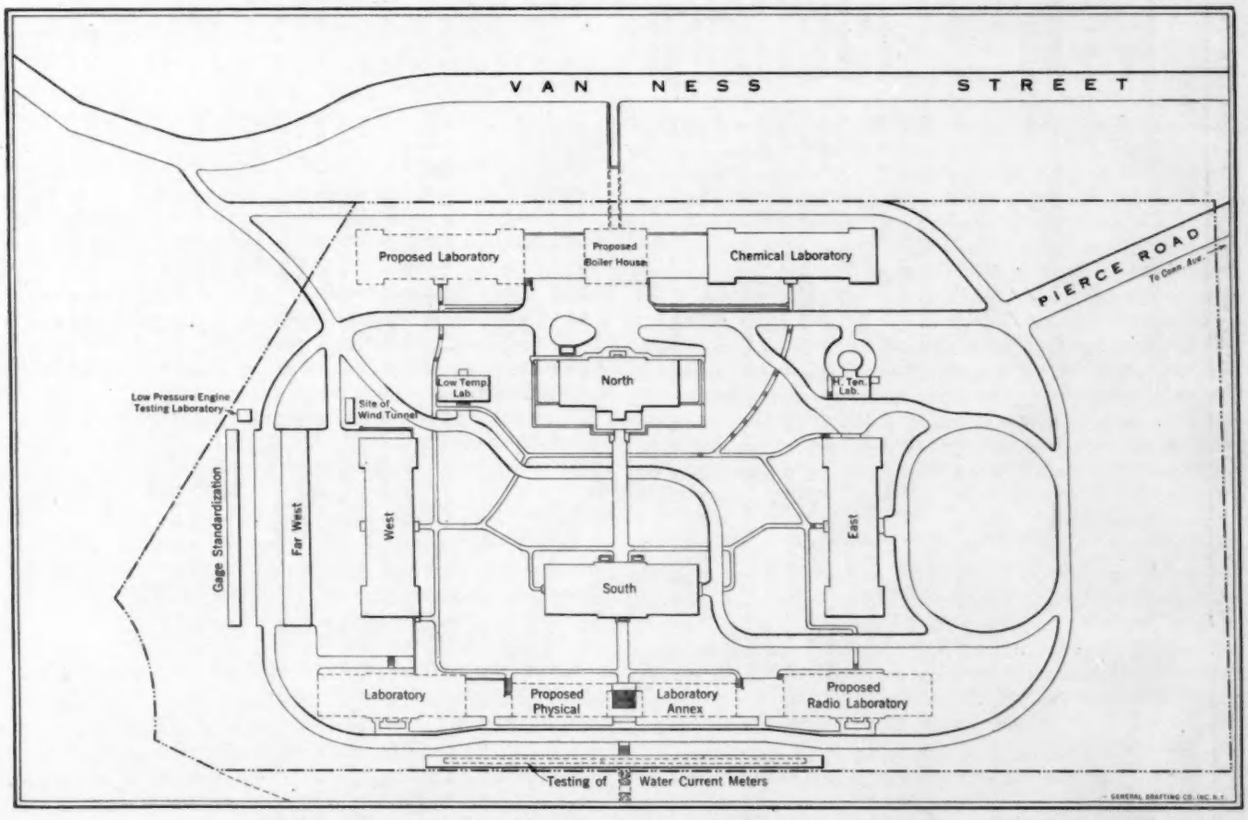
The working force of the Bureau now comprises about 600 people, of whom 60 per cent are scientifically trained men. These include expert physicists, chemists, and engineers. The greater part of this organization is concentrated at the headquarters of the Bureau in Washington. There is, however, a general laboratory at Pittsburgh for testing structural material and minerals and a cement laboratory at Northampton, Pa. In addition the Bureau does considerable field work, and its representatives are scattered all over the country engaged in investigations of various kinds.

In order to carry on the work most efficiently, the scientific and technical staff of the Bureau is separated into divisions, these being based upon the nature of the expert service to be rendered rather than upon the classes of standards. There are now eight of these divisions, dealing with problems relating to weights and measures, heat and thermometry, electricity, optics, chemistry, general materials, engineering research, and metallurgy. The first four of these divisions are engaged in consideration of more purely scientific problems, while the work of the last four deals more specifically with large and important classes of materials. The work of the latter is just as scientific in character, but deals with manufactured products.

With the exception perhaps of the Optics Division, the activities of all of the divisions will be of interest to members of the Society. Before describing some of the work now under way it will be well to outline the nature of the work undertaken by each division.

Weights and Measures. This division handles questions relating to standards of length, mass, volume, time, density, whether arising in connection with the precision standards used in scientific investigation, the master standards of manufacturers, or the ordinary weights and measures of trade. Quality or performance standards would be considered by this division, provided any of the measurements mentioned form the fundamental and most important factor.

Heat and Thermometry. This division has to do with heat standards, the testing of heat-measuring apparatus, the determination of heat constants, and, in fact, with

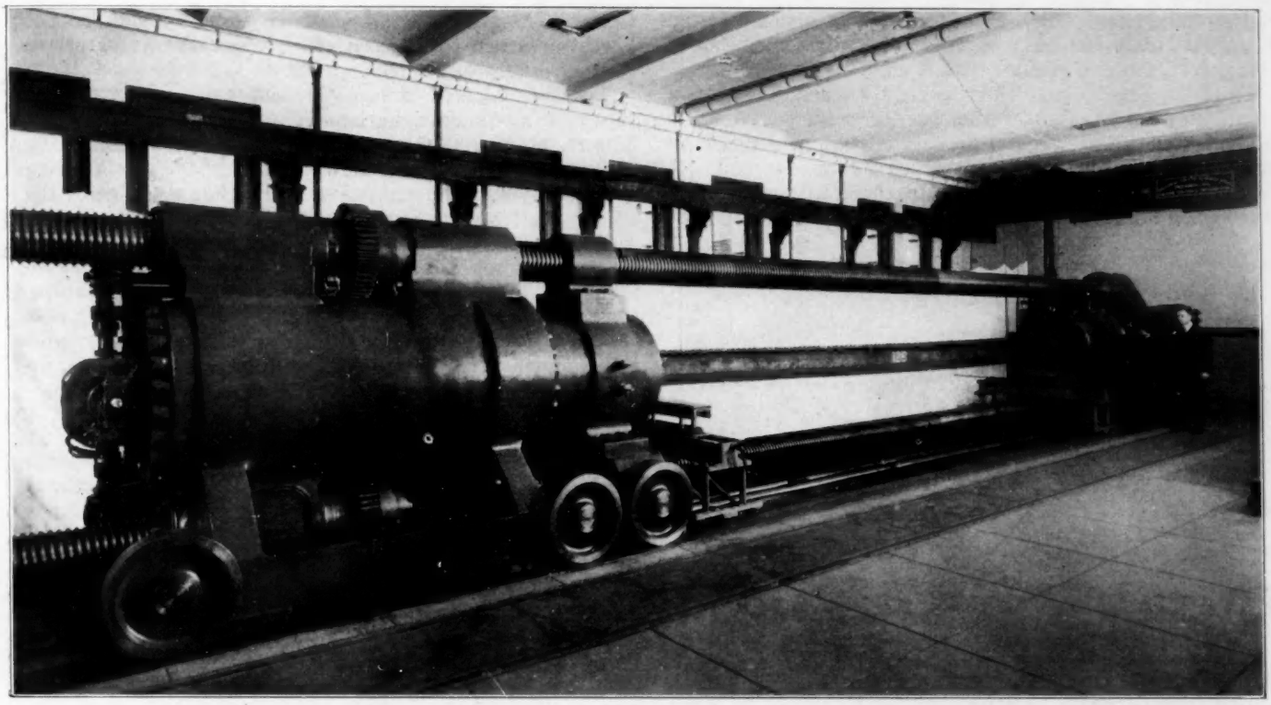


LAYOUT OF BUILDINGS AT NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.

The buildings are used as follows: Far West, foundry, paper mill and wood shop; West, heat, metallurgy, engineering testing and miscellaneous materials; North, plant and shops; South, administration, weights and measures, optics, library; East, electricity.

TABULATION OF ACTIVITIES OF THE NATIONAL BUREAU OF STANDARDS

FUNCTIONS OF BUREAU	Development, construction, custody, and maintenance of reference and working STANDARDS Their intercomparison, improvement, and application in science, engineering, industry, and commerce.				
TYPES OF STANDARDS	1—*Standards of Measurement* Reference and working standards for measurements of all kinds, including fundamental and derived *standards of measurement* for expressing the quantitative aspects of space, time, matter, energy, motion, and of their interrelations. By definition, specification, or material standard, covering, for example, length, area, and volume; mass, weight, density, and pressure; heat, light, electricity, and radioactivity, including quantity, flux, intensity, and density.	2—*Standard Constants* Natural standards or the measured numerical data as to materials and energy, known as physical or *standard constants;* for example, the fixed points or quantities which underlie scientific research and industrial processes when scientifically organized. Mechanical equivalent of heat, light, and electricity, and of gravitation; specific densities; viscosities; melting and boiling points; heat capacity; heats of combustion; velocity of propagation of light; conductivities of materials to heat and light; electrochemical and atomic weights and similar magnitudes determined experimentally with maximum precision and referred to fundamental standards of measure.	3—*Standards of Quality* Specifications for material (by description, sample, or both), known as *standards of quality,* fixing in measurable terms a property or group of properties which determine the quality. The numerical magnitude of each constituent property pertinent to the quality involved, and specific magnitude in units of measure of such significant factors as uniformity, composition, form and structure.	4—*Standards of performance* Specification of operative efficiency or action, for machines, and devices, *standards of performance,* specifying the factors involved in terms susceptible of measurement. Numerical statement of speed, uniformity, output, economy, durability, and other factors which together define the net efficiency of an appliance or machine.	5—*Standards of Practice* Codes and regulations impartially analyzed and formulated after study and experiment into *standards of practice* for technical regulation of construction, installation, operation, and based upon standards of measurement, quality, and performance. Collation of standard data, numerical magnitudes, and ranges of the pertinent factors defining quality, safety economy, convenience, and efficiency.
PURPOSE OF STANDARDS	(a) To aid *accuracy in industry* through uniform and correct measures; (b) To *assist commerce in size-standardization* of containers and products; (c) To *promote justice in daily trade* through systematic inspection and regulation; (d) To facilitate *precision in science* and *technologic research* through calibration of units, measures, and instruments involved.	(a) To *serve* as an *exact basis* for scientific study, experiment, computation, and design; (b) To *furnish* an *efficient control* for industrial processes in securing reproducible and uniformly high quality in output; (c) To *secure uniformity of practice* in graduating measuring instruments, compiling tables, in standards of quality and performance, and wherever uniformity is desirable; (d) To *aid laboratory research by reducing errors* and uncertainty caused by the use of data of doubtful accuracy.	(a) To secure *high utility* in the *products* of industry by setting an attainable standard of quality; (b) To furnish a *scientific basis* for *fair dealing* to avoid disputes or settle differences; (c) To *promote truthful branding* and *advertising* by suitable standards and methods of test; (d) To *promote precision* and *avoid waste* in science and industry by affording quality standards by which materials may be made, sold, and tested.	(a) To *clarify the understanding* between maker, seller, buyer, and user, as to operative efficiency of appliances and machines; (b) To make *exact knowledge the basis of* the buyer's choice; (c) To *stimulate and measure mechanical progress.*	(a) To *furnish* for each utility a single *impersonal standard* of practice as a *basis for agreement* of all interests clearly defined in measureable terms; (b) To *insure effective design* and *installation* of utilities of all kinds; (c) To *promote safety* and *convenience* in the maintenance and *operation* of such utilities; (d) To *secure uniformity of practice* where such is practicable, and *effective alternates* in other cases.



BUREAU TESTING MACHINE—CAPACITY 2,300,000 LB. IN COMPRESSION AND 1,100,000 LB. IN. TENSION

all investigations of quality or performance in which heat measurement is the essential factor.

Electricity. This division deals with standards and measurements, constants, properties of materials, or the performance of equipment of an electrical nature.

Optics. The Optical Division handles such work as spectroscopy, polarimetry, color measurement, principles of optical instruments, and measurement of optical properties of materials.

Chemistry. The Chemical Division cooperates with every other division of the Bureau, and also takes care of the questions of a purely chemical nature that fall within its functions. Its work is especially closely related to that of the Metallurgical Division.

Materials. The work in structural engineering and miscellaneous materials includes the investigation of the strength, hardness, elasticity, plasticity, permeability, composition, structure, and other physical properties of structural and miscellaneous materials, such as cement, stone, clay, lime, paper, textiles and rubber, including laboratory and field work in developing methods of test, standards of quality, and the relation of quality to the efficient utilization of such materials.

Engineering Research. An important part of the Bureau's work is research on instruments, devices and machines with a view of developing the best methods of tests and the specification of the standards of performance for such appliances. For example, under this head would come the development of tests of such appliances as fire extinguishers, radiators, and vacuum cleaners.

Metallurgy. The Metallurgical Division deals with questions pertaining to the manufacture, specifications, testing and use of metals and their alloys.

As stated previously these divisions are handling an immense amount of work for the general public and for various departments of the Government. The Government work is exceedingly important at the present time in carrying on the war. The War and Navy Departments are using the Bureau for all sorts of testing purposes. It is taking an important part in the aeronautical program to be carried out by this country. The Bureau is making extensive preparations to test the gages that will be required in the manufacture of ammunition and guns. In spite of the enormous amount of special work required on account of war activities, the Bureau is carrying on its general industrial work. A large number of its members are engaged continually in comparing standards of measurements for the general public. This work must, of course, be continued.

The knowledge gained by the Bureau in its various investigations and testing activities is given to the public in the form of suitable publications. The Bureau is also in touch with a large number of manufacturers and others interested who are seeking information as to standards of measurement, properties of material and the fundamental physical and chemical principles involved in using these standards and materials. They are continually seeking information as to how to initiate and carry on scientific investigations and tests on their own account.

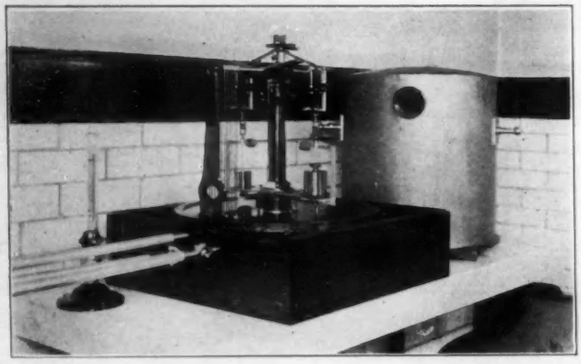
WEIGHTS AND MEASURES

The most important work of the Weights and Measures Division at present is probably the testing and inspection of gages to be used in munitions work. This will consist in the checking of gages used by Government inspectors for the final product and also in the testing of master gages, which will be used mostly by the manufacturers' Government inspectors of munitions.

The experts of the Bureau have made a study of the methods followed in foreign countries and have made use of the services of the best authorities in the world on the manufacture of scientific instruments. Some of the

testing machinery will be imported from abroad, but a large part of it has been purchased in this country or is being designed and constructed at the Bureau.

It is expected that some twenty thousand gages a month will be handled at the Bureau after the work is well started. The gages purchased in this country by England will probably be inspected at the Bureau. A separate building recently put up to test specimens of stucco will be devoted to the gage work. The equipment



Precision Vacuum Balance With Cover Removed

is being installed in this building and a force of gage experts is being mobilized. The duties of these experts will include the inspection of the primary or other gages required.

The Weights and Measures Division handles the testing of aeronautical measuring instruments. A brief history of the work the Bureau has done with aneroids will be of interest as indicating both the thoroughness of the methods followed and the beneficial effect the work of the Bureau has on commercial design. The subject was first considered by the Bureau about seven years ago. At that time the aneroids being purchased by the Government were subject to considerable drift and would not register the altitude accurately at the high-temperature and low-pressure conditions encountered. The Bureau investigated the trouble and found that the vacuum box was at fault. As a result of the Bureau's investigation the makers can now provide instruments that are correct under the different operating conditions within very close limits.

The Bureau had under way until interrupted by the war an important investigation of the stiffness of elastic systems. This work was started in order to fix reasonable rejection limits on aneroids subject to temperature, but the results are not limited to the aneroid. Enough has been done already to afford a rational basis for designing instruments whose action depends on the deformation of some form of spring; it remains only to determine the empirical constants which are needed. This particular investigation is an example of one of the many that are being conducted by the Bureau, the result of which will be of immense value to the manufacturing interests of the country.

At the present time about one hundred aneroids are given a standard acceptance test each month. These are mostly instruments purchased for the Army and Navy. The division will be greatly enlarged just as soon as the aircraft program is under way, and will be in a position therefore to handle all the Government work.

The aneroids are subjected to preliminary and final tests under different pressure and temperature conditions. The preliminary pressure test is made at the lowest pressure (or highest altitude) at which the instrument is likely to be used.

The readings of the instrument are compared with those of a standard barometer. The limiting error is 300 ft. at 10,000 ft. altitude and 500 ft. at 20,000 ft. altitude. Immediately following this first test, a reading is taken at atmospheric pressure in order to judge of the after effect, which should not exceed 2 per cent.

The testing of the other aeronautic measuring instruments such as tachometers, air speed indicators, inclinometers, compasses and radiator temperature indicators is rapidly being established on a basis similar to that of the aneroid work; the Bureau cooperating with the manufacturer in his endeavor to improve the construction to meet the needs of the aviation service.

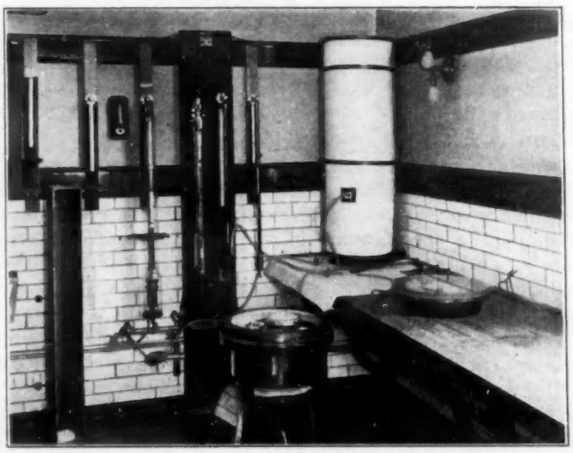
Heat and Thermometry

The Heat Division is conducting considerable research work on the standardization of instruments and methods for measuring temperature. One of its most important activities is the testing of pyrometers of both the optical and radiation type.

The Bureau has constructed special resistance thermometers required for the determination of the melting point of pure samples of such metals as copper, aluminum and zinc. These standard melting-point samples are now available. Their melting point is accurately determined and certified by the Bureau, and they are then supplied to steel and other industries in which it is necessary to measure accurately high temperatures. The samples can be used conveniently to check the accuracy of the pyrometers used by such industries.

Work of Electrical Division

The magnetic method of testing steel for the determination of its mechanical properties has been developed by members of the Electrical Division. This work has been under way for several years and large manufacturers are already taking advantage of the work done by the Bureau. Investigations are being conducted to determine the relation between the mechanical and magnetic properties of steel. In time it is believed that it will be possible to determine the properties of the metal without harming in any way the original sample, as must occur with many tests now in use. Either the finished product or the raw material can then be tested and any defects will be at once detected.



Testing of Aneroid Barometers

In the present application of this method to commercial testing the procedure is largely empirical. The magnetic properties of good and bad materials are determined and a suitable criterion settled upon.

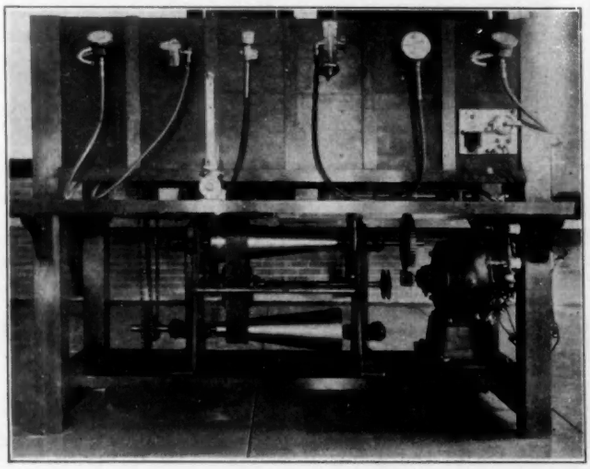
The Bureau has made a number of tests to determine the effects of heat-treatment on the magnetic properties of steel. It has been found that any one of several magnetic characteristics can be used as a criterion for the proper quenching. Tests are being made of high-speed drills, ball-bearing races and also the tubes from which races are made. It has been found that the method works well in detecting bad spots in material of hollow cylindrical construction. Other tests are being carried on to show how the progressive deterioration, owing to repeated stresses, may be traced by magnetic changes in the steel.

Preliminary specifications for the purchase of spark-plugs have recently been prepared by the Bureau in collaboration with the Aviation Section of the United States Army. In connection with these specifications, the Electrical Division is making a thorough investigation of the qualities required for plugs subjected to heavy duty. Special porcelains have been made at the Bureau's laboratory at Pittsburgh and the samples are being given an electrical test. Plugs have also been tested in actual operation at the gas engine testing laboratory in connection with the Bureau.

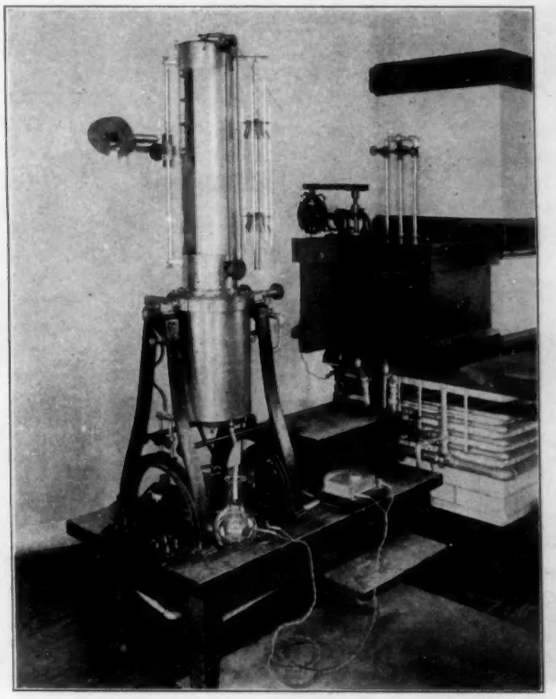
The specifications state that the plugs for aviation service must be subjected to an alternating current of 25,000 volts for two minutes. The porcelain is to be given a heat test at 300 deg. cent. for fifteen minutes, and then it must be possible to drop them in water without their cracking. In order to test the air-tightness of the plugs, the specification provides that they must be subjected to a pressure of 15 kg. per sq. cm. when immersed in oil at a temperature of 200 deg. cent. This pressure must be continued for five minutes without bubbles appearing.

Chemical Division

The work of the Chemical Division has included the study of lubricants. A method for determining the tendency of oil to carbonize has been developed at the Bureau, and on account of its rapidity compared with other methods, has come into wide commercial use. The so-called demulsibility test has been worked out by the Bureau. It has been found that when oils are vigorously stirred or shaken with water, more or less permanent emulsions are produced. The quality of the oil is indicated somewhat by the rate of separation of the emulsions produced in the oil. A high demulsibility indicates an oil of good quality.



Speedometer Testing Apparatus



Testing Apparatus for Standard Thermometers

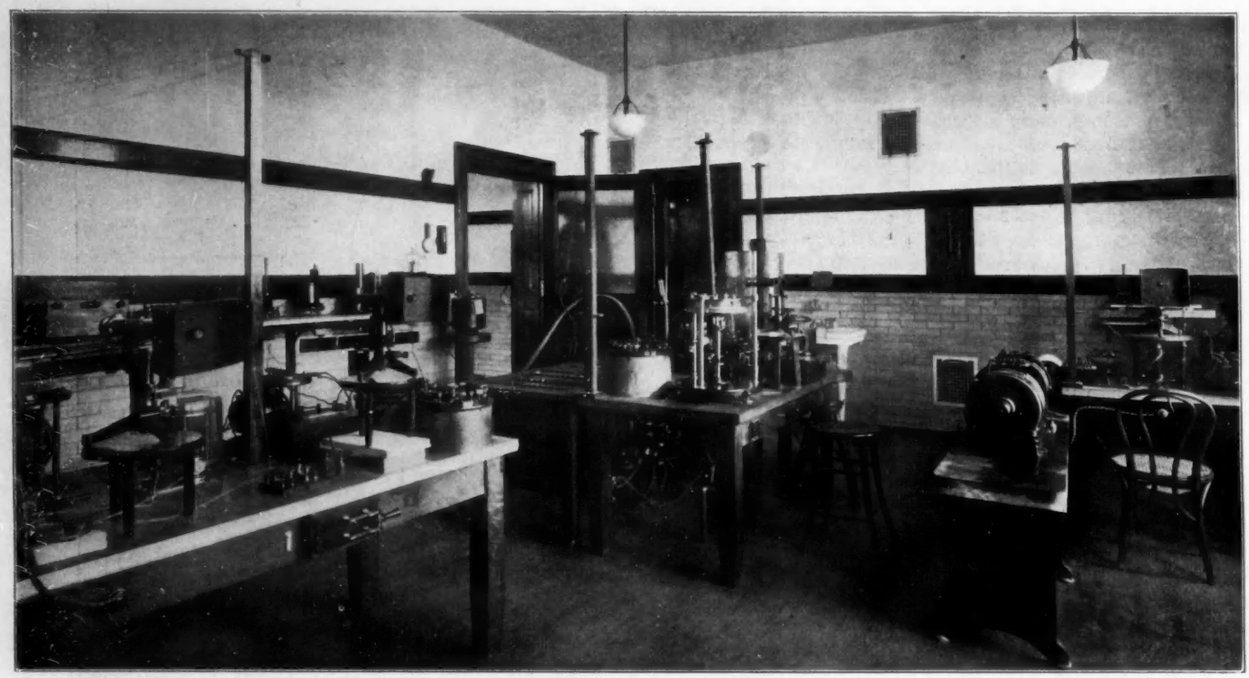
An important part of the Division's work has been the preparation of material specifications for the departments of the Government. Acceptance tests have been made of a large number of materials purchased by the Government. This work, of course, is continuous. At present the Division is cooperating with the Advisory Committee for aeronautics in the preparation of specifications to be used in purchasing aviation engine lubricants.

The Chemical Division prepares standard analyzed samples of iron and steel. These are sold at a nominal charge to chemical laboratories throughout the country and are used to check the results obtained by such laboratories in their own analytical work. The samples are certified by the Bureau as to their chemical compositions.

An extensive study of ladle-ingot test methods is being conducted by the Chemical and Metallurgical Divisions. It has been found that the results obtained from analyzing such ingots differ widely from those obtained from the finished article. This is of special importance at present in connection with the testing of aeronautic steel, for which special material is required and which is worked at a low factor of safety. It is hoped as a result of the work now being done by the Bureau to determine just what test is needed in order to obtain a satisfactory finished product. The Chemistry Division is also engaged in the study of so-called dopes for airplane fabrics. Glue used in the construction of the planes, and varnish for use on aircraft, and in research involving aircraft problems the Chemistry Division conducts such analysis and minor chemical investigations as may be required.

Work of Metallurgical Division

Among the problems of the Metallurgical Division is the investigation of the properties of metals as influenced by heat-treatment. So far the study of heat-treatment



TYPICAL EXAMPLE OF ELECTRICAL LABORATORY SHOWING INSTRUMENTS READY FOR ACTION

has been confined to carbon steel, although it is expected that alloy steels will be investigated later. The work at present is concentrated mainly on the determination of the stresses in quenching steel. The stress is being measured under different conditions, and the corresponding drawback temperatures are determined.

A systematic study of the transformations of steel is being conducted, using specially prepared samples of highest purity. Optical pyrometers are used to determine the melting-point of slag, ingots (pouring temperatures), and of furnace gases. This work has been done at several steel plants. It is believed that the results obtained will demonstrate the practicability of pyrometric control of the operations of open-hearth furnaces and ingot practice.

Considerable work is being done in investigating brass and other non-ferrous metals. This has included a study of the failure of structural brass and of the problem of deoxidizers for bronzes and brasses. The foundry is investigating the effect of impurities on alloys.

The subject of protective coatings for metals is especially important to the aeronautic industry at this time. This division is therefore studying the coatings used for protecting steel from rust; the hydrochloric acid, basic lead acetate, sherardizing and galvanizing methods being under consideration. Some of these coatings are now being subjected to actual test, a salt spray being continually applied and the time recorded when rust appears.

The division is also investigating the possibilities of obtaining a rolled aluminum alloy for use in aircraft structural members.

ENGINEERING RESEARCH AND TESTING

The new low-pressure engine testing laboratory is now well under way. This will be used for study of the performance of the standardized All-American aviation engine at high altitudes, also for any other type of aircraft engine that may need experimental investigation of this nature. A special building is being constructed in which the engine can be mounted in a vacuum chamber. The pressure in this chamber can be reduced to one-half an atmosphere, corresponding to an altitude of over 20,000 ft. The temperature of the air surrounding the engine and also the humidity and temperature of the air supplied to the carbureter can be varied at will. The velocity of the air circulating past the engine will be controllable so as to give actual operating conditions.

At the Bureau there is a gas-engine testing laboratory, equipped with several types of modern engines, electric dynamometers and the other apparatus necessary for making complete tests. Other equipment of this kind is being installed for making a study of the physical properties of air-fuel mixtures for different fuel, particularly with reference to high altitude conditions. The effect of dryness of mixture on engine behavior is also being investigated.

A comprehensive test of spark-plugs has been carried on in cooperation with the Electrical Division. The main object has been to study the behavior of the plugs as affected by different ignition appliances.

The principles underlying radiator constructions are now being studied, with a view of improving the radiators used in aircraft and other automotive apparatus. Model radiators have been secured from practically every manufacturer. These are being tested in a model wind tunnel. It is hoped as a result of these tests to determine the best form of cellular construction and to suggest a design for a standard radiator section.

The Engineering Research has to do with developing tests of steam-gages, speedometers, water-meters and other instruments. It recently examined a number of fire-extinguishers suggested for use on airplanes. The fluid was analyzed to determine whether it contained improper or harmful substances and the working parts inspected for excellence of the general design. The extinguishers were operated at a temperature of 40 deg. below zero to

see if they would work under actual flying conditions. The Bureau is working on a method for distributing the liquid from the fire-extinguishers so that it will cover all parts of the airplane.

Structural Engineering and Miscellaneous Materials

Most of the tests on strength of materials handled by the Bureau are made by the Structural, Engineering and Miscellaneous Materials Division. Tests are made of every description—tensile strength, transverse bending strength, hardness, cold bend, repeated stresses, compressive strength, shearing strength—not only for metals, but also for other materials used in the industries.

Among the investigation work now in progress are such subjects as the study of spruce, with special reference to airplane construction, the investigation of propeller blades, struts, glued junctions and other structural airplane elements.

The Bureau is making a study of the fabrics for covering wings, bodies and other parts of aircraft, on account of the shortage of linen formerly used for the purpose. Various grades of cotton and of cotton and silk mixtures are being investigated. These are being tested for strength and compared as regards weight and number of threads per inch. The Bureau is trying to determine the shape of a desirable elastic curve for these fabrics. A study is being made of their elastic properties after exposure to the elements. It is hoped to develop cotton, silk and ramie so that all can be used satisfactorily for various kinds of aeronautic work.

The division is testing balloon fabrics in respects to gas-tightness, resistance to tearing, and to detonation. Cotton and not silk is being used for this purpose on account of the electrostatic effect of the latter.

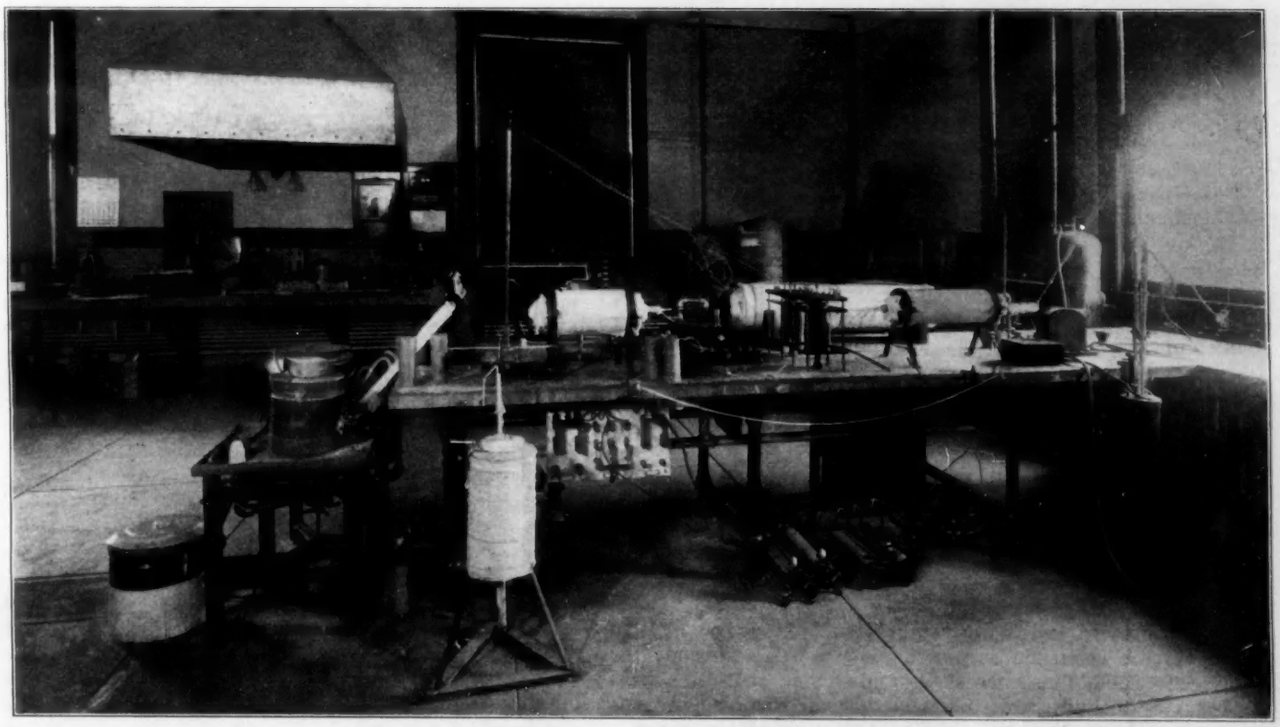
A number of machines have been built at the Bureau for the testing of rubber goods. One such machine is used to test the wearing qualities of the sole leather for Army shoes. It is also designed to test the wearing qualities of the rubber tread on automobile tires. This machine is so arranged that the relative loss of volume due to wear of the material can be measured. Another machine is used for determining the adhesion between layers of canvas and rubber. Samples of belting, hose and tires can be tested and the force necessary to separate the plies measured.

Conclusion

The foregoing is an extremely brief review of the activities of the Bureau. A few of those in which the members of the Society are particularly interested have been considered. It would be impossible within the scope of such an article as this to give a complete account of the hundreds of things being done.

The Bureau is a governmentally-operated link between science and industry. It studies the problems of industry from a scientific standpoint. The results obtained are therefore of immediate value both to the consumers and the manufacturers of the country. An institution working constantly for the interests of the nation, the Bureau deserves and is always inviting the cooperation of all citizens.

It is now generally recognized that the State can act as a most powerful agency in developing the resources and extending the commerce of its citizens. The work of the Bureau in promoting national efficiency and economy is therefore of the utmost importance during the present conflict and will be even more so in the period of commercial adjustment that must follow its termination.



Pyrometer Testing Laboratory in West Building at Bureau

SIDE GUIDE & GRIPPER

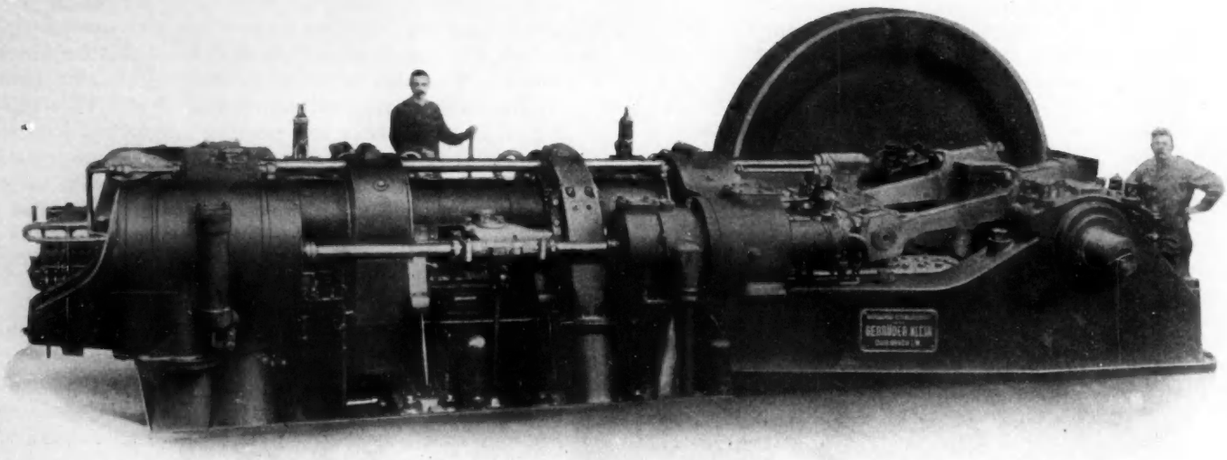


Fig. 1—Experimental 1000-Horsepower Two-Cylinder, Double-Piston, Tandem, Direct-Reversible Junkers Engine

Construction of Junkers Engine

By PHILIP L. SCOTT* *(Non-Member)*

METROPOLITAN SECTION PAPER *Illustrated with* CHARTS AND PHOTOGRAPHS

IT was my good fortune to spend the past year (1916) in the laboratory of Professor Junkers at Aachen, Germany, studying at first hand the Junkers double-piston engine. Since returning to this country I have met with many divergent views as to the capability of this engine and will therefore confine myself to a discussion of personal experiences and of certified reports of tests relating to the performance of the engine.

In the Diesel-engine cylinder potential chemical energy is transformed into kinetic physical energy in a space about one two-hundredth part of that of a steam plant of equal capacity, the boiler alone considered.

The difficulty of controlling this exceedingly violent transformation is only too well attested by the troubles attending early developments and unfortunately still far from being overcome.

PROGRESS OF DEVELOPMENTAL WORK

The problem was first attacked in the year 1892 by Professor Junkers and Mr. Oeschelhauser in connection with the construction of a gas engine, which never was successful because the problem of introducing gas into the cylinder of a double-piston engine had not been solved. During the following sixteen years labor was continued unremittingly on the study of transformation in metal containers of the chemical energy in readily combustible hydrocarbons into the potential energy of gas under pressure.

Experiments with the combustion bomb came first in which the influence of piston motion was removed; the effect of eddying, pressure, and temperature on heat transfer to and through the metal wall was also investigated. Then came experiments on a special apparatus having free pistons operating in cylinders that could be completely closed at and after ignition. In this way the influence of gas motion to and from the cylinder was eliminated.

So, one by one, the various problems were solved and valuable information was gained regarding the transfer of heat from a gas to and through a metal surface. The final experiments were made on a compound internal-combustion engine using an explosion pressure of 250 atm. (3675 lb. per sq. in.) in the high-pressure cylinder.

After sixteen years of research, the latter part of which was devoted entirely to the idea of using oil as a fuel, the first double-piston engine was built in 1908. The first engine is still running (a tandem cylinder was added in 1910) and running so well that it is often used for exhibition and demonstration purposes. It is a 150-hp., two-cylinder horizontal tandem engine. The bore is 200 mm. (7.875 in.); stroke, 800 mm. (31.5 in.); revolutions per minute, 220; normal mean effective pressure 10 atm. (147 lb. per sq. in.); overload mean effective pressure 15 atm. (220 lb. per sq. in.).

METHOD OF OPERATING DOUBLE-PISTON ENGINE

The two-stroke constant-pressure cycle is used, giving a power impulse every revolution and requiring a combustion pressure but little higher than the compression pressure. This cycle as used by all Diesel engines must be carefully distinguished from the one on which most gasoline engines operate; the latter has a combustion or explosion pressure much higher than the compression pressure. The constant pressure cycle requires a combustion of the fuel such that the pressure neither rises nor falls during the period that follows immediately after the compression period. As a result the ratio of mean effective pressure to combustion pressure can be high.

The Junkers engine has two pistons operating in the

*Engineer, De La Vergne Machine Company.

same cylinder and moving in opposite directions. The inner piston is connected to the center crank of a three-throw crankshaft; the outer piston is connected through a yoke and side-rods to the outer cranks of this same shaft section. In some designs, in which the power can be taken advantageously from two shafts, the side-rods are dispensed with and a crankshaft is placed at each end of the cylinder, each piston being directly connected to the nearest shaft. This construction lends itself admirably to submarine work. The pistons are kept in proper relation by gearing or connecting-rods lying alongside the first cylinder of the engine. The preponderating advantage of this mechanical arrangement is the perfect balance of mass attainable.

The constant-pressure cycle is applied to this mechanism as follows: In Fig. 2, *A* the pistons are approaching each other, compressing air alone, line *FA* in the ideal card. Just before the point *A*, when the pressure is about 48 atm. (705 lb. per sq. in.) and the temperature of the air about 1200 deg. cent. (2192 deg. fahr.), the fuel injection begins and the pressure rises to about 50 atm. (735 lb. per sq. in.). Injection continues, the pressure remaining constant, along line *AB*. At point *B* the fuel injection is stopped and expansion of the gases commences along line *BC*. At point *C* the pistons have reached the position shown in Fig. 2, *C*. At this point the outer piston opens a row of ports and the gases exhaust to almost atmospheric pressure; line *CD* in the card. At point *D* the pistons are in the position shown in Fig. 2, *D*, and the inner piston is uncovering a second row of ports through which the scavenging air enters. Scavenging takes place along lines *DE* and *EF* in the card, the pistons being in the position indicated in Fig. 2 *E*. Cold clean air under a pressure of 1.5 to 2 lb. per sq. in. rises through the cylinder, forcing the exhaust gases out ahead of it. A charge of pure air is left in the cylinder when the ports are again closed and compression begins as indicated in Fig. 2, *F*. This completes the cycle. It will be noted that this is the best method of scavenging possible. How closely the Junkers engine approximates this cycle is shown by the photograph of an actual indicator card, Fig. 3.

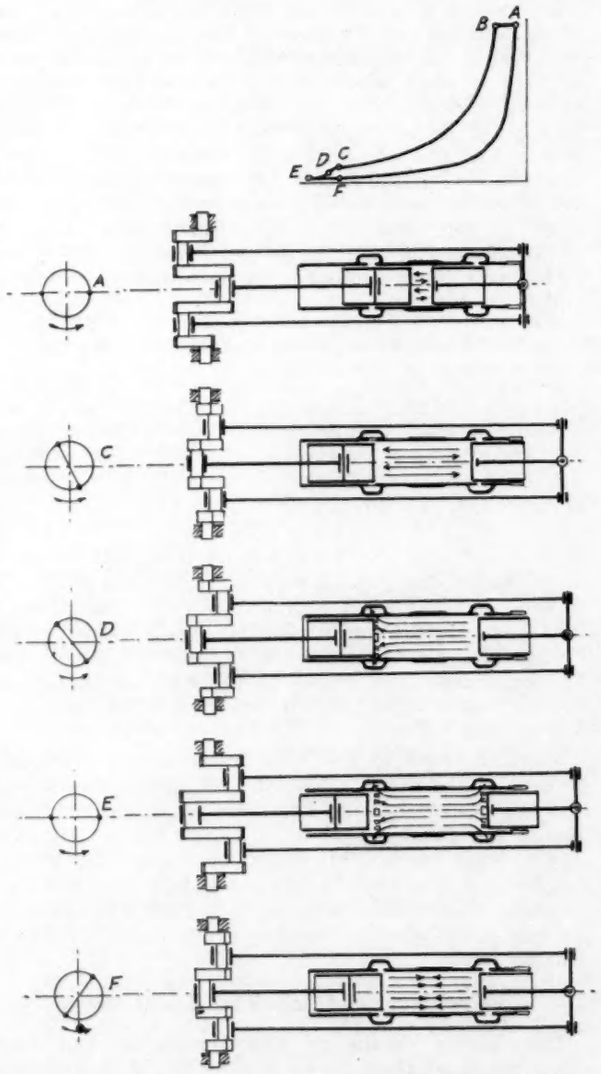


FIG. 2—CYCLE OF THE JUNKERS DOUBLE-PISTON ENGINE

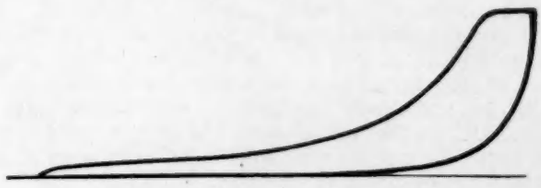


FIG. 3—REPRODUCTION OF ACTUAL INDICATOR CARD

PRESENT STATUS OF ENGINE

The engine met with severe trials when first placed on a commercial basis, a notable example being the vertical tandem 800-hp. engine on the ship "Primus." Mistakes are often most useful occurrences and the difficulties met have greatly accelerated the development of the present designs, which have perfect records to show.

There are now many prominent foreign licensees, among whom are Nobel & Sons, Russia; Actien Geselschaft Weser, Germany; Doxford & Sons, England; Du Jardin, Belgium; and the Allgemeine Electricitäts Gesellschaft (A.E.G.), Germany.

The engine was never built commercially by Professor Junkers himself until just at the outbreak of the war.

Since 1914 amazing strides have been made in Germany. The output of the A. E. G. has been so large as to cause this company and the Hamburg-American Line to combine in building Junkers-engined vessels of medium and large tonnage. An island in the Elbe has been purchased for the yards and factory. The A. E. G. at first built high-speed types, but is now taking up the large marine engine just mentioned and also submarine, auto-truck and airplane engines.

In addition some 700-hp. engines, 400-mm. bore (15.7 in.) by 800-mm. stroke (31.5 in.) of the two-cylinder horizontal tandem type have been built by Erhardt & Sehmer. One of these is now in operation in a mine. There are 450-hp. horizontal tandem engines running at 90 r.p.m. for shallow-draft boats in the Donau River. Doxford & Sons have built a 500-hp. vertical single-cylinder engine. The locomotive problem has been carefully studied and several projects made, but no machine has as yet been constructed.

Of the machines that I have seen myself or whose operators I have known, there are two 400-kw. direct-coupled dynamo units on one of the German cruisers now in active service; a 250-hp. engine that served continu-

ously for a year for factory power; a similar machine that has operated a government tugboat for a year and is to the best of my knowledge still in operation; a 100-hp. engine on a small yacht; a 1000-hp. stationary machine and a 150-hp. stationary machine. As stated, these are the engines of which I have personal knowledge and are but a few of the whole number in operation.

I saw but was not allowed to examine carefully an airplane engine of 200 hp. It is probable that a similar one of 400 hp. is now on a military Junkers airplane. Also an auto-truck engine was reported to have been successful on the test stand of the A. E. G. and a 140-hp. farm-tractor engine was ordered by a Russian firm just before the outbreak of the war.

Airplane, Truck and Tractor Engines

The airplane engine was a 200-hp. machine running at 1000 r.p.m. There were four cylinders lying horizontally with a crankshaft at each end and no side connecting-rods. The crankshafts were held in proper relation by gearing at one end and the propeller was driven by an intermediate gear in this train. In the new airplane

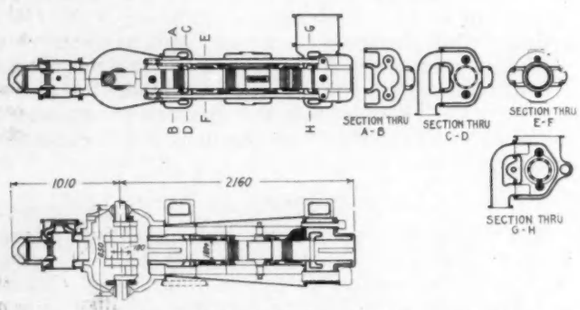


FIG. 4—TYPE OF ENGINE USED FOR TRACTOR SERVICE

engine, which should now be in service, direct injection of fuel is used. No great difficulty with scavenging at high speed has been encountered. In the Aachen Laboratory successful experiments with direct injection were carried out on an 80-hp. engine running at 800 r.p.m.

The auto-truck engine was reported as successful on the test stands of the A. E. G., but no details were available.

Fig. 4 gives some idea of the tractor engine. Direct injection of fuel is used on the later designs. The air compressor has been removed.

DETAILS OF MARINE AND STATIONARY TYPES

Most of my time was spent on a marine engine of 250 hp. and a stationary type of 1000 hp., Fig. 1.

The marine engine, Fig. 5, was of the three-cylinder direct-reversible type, giving 250 hp. at 250 r.p.m.; the bore was 200 mm. (7.875 in.), and the stroke 700 mm. (27.5 in.); the normal mean effective pressure was 10 atm. (147 lb. per sq. in.), and the overload 15 atm. (220 lb. per sq. in.); the pistons were cooled, but without external connection. It had a three-stage air-compressor. This machine was connected to a Junkers hydraulic dynamometer for test purposes.

Two types were developed from this machine. A 400-hp. tugboat engine designed to run at 160 r.p.m., built without crossheads in order to reduce the height, and an engine of the same stroke and bore with crossheads developing 400 hp. at 160 r.p.m., but designed to develop 740 hp. with maximum mean effective pressure and a speed increase of 15 per cent.

The original engine from which these engines were developed had a speed range of from 30 to 300 r.p.m., and a mechanical efficiency of 73.5 per cent (including power for pumps and air compressor). It had run for a year in factory service and had been sent to Aachen for experimental purposes in connection with the use of tar oil as a fuel.

Tar oil is little known in America as a Diesel engine fuel, but it is the most difficult fuel to burn properly, though hardly more viscous than water and containing no asphalt. The burning of oils having a high asphalt content is not very difficult, although combustion must be perfect in order to avoid the heavy pitch-like substance that slowly collects on the pistons and prevents lubrication.

Tar oil is a mixture of the three fractions next to the last, pitch, in the distillation of coal tar. It is dark brown in color, a little heavier than water (specific gravity 1.040 to 1.150) and contains a hydrocarbon similar to carbolic acid in structure, which gives the oil a corrosive action on metal and makes a strong irritant on the skin. Its use in Germany was becoming a necessity, owing to the scarcity of crude oil distillates.

Perhaps because its hydrocarbons belong to the benzol ring and not to the benzine chain, this oil is excessively tenacious of its chemical energy, and as compared with crude oil distillates, requires an immense amount of heat to start oxidation. A greater initial temperature is necessary for tar oil to start combustion, but, because of its tendency to burn explosively once the reaction has started, this is an undesirable feature the moment combustion begins. It was not an easy problem, but it was solved eventually and the engine can be started cold (16 deg. cent., or 61 deg. fahr.) with tar oil. It is the only engine that has accomplished this. The double piston lent itself admirably to the solution of this difficulty.

Conditions During Injection of Fuel

Because of the very high compression (about 700 lb. per sq. in.) in the Junkers engine the temperature in the combustion space is much higher and the pistons become and are allowed to remain considerably warmer than is the usual practice. The oil is sprayed into the cylinder in two fans, one directly across the face of each piston when they are at the inner dead center. The high heat capacity of the iron promotes warming of the oil far more readily than air, aiding the initial combustion. But as soon as the pistons recede they draw with them the thin layer of burnt gases formed by the initial combustion and lying between the piston head and the oil spray. The hot metal then exerts no influence on the oil, and two oil layers inclose the hot compressed air and retard the explosive effect.

Since injection of fuel takes place during from 30 to 40 deg. of the crank circle, the oil spray is relieved of this too intense heating necessary to initial combustion during the greater part of the injection period. In a single-piston engine this would be impossible, since, if the fuel valve is vertical, the oil strikes the piston continuously during the injection; if the valve is horizontal, the fuel spray always remains in close proximity to the cylinder head.

Valve Gear to Attain Wide Speed Range

The marine engine is direct-reversible and has a speed range of from 30 to 300 r.p.m. A special valve gear makes possible this wide range by changing the

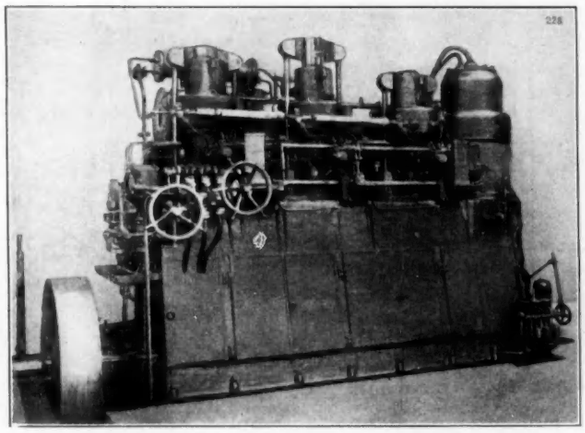


FIG. 5—250-HORSEPOWER EXPERIMENTAL TUGBOAT ENGINE

angle of advance, the period of injection and the lift of the fuel-valve needle with each variation in speed or load. These changes are necessary to permit slow speed and high-speed operation and to obtain fuel economy at light load.

With fixed cam action the speed of injection of the fuel (time element of injection) remains constant regardless of the engine speed, since it is dependent solely on the injection-air pressure. Also the speed of combustion remains constant. Hence, when the engine runs slowly and the angle of advance, period of injection and valve lift all remain the same as for high speed, the fuel will be shot into the cylinder and will have time to burn, perhaps even before the pistons have passed their inner dead center. Of course, then, there is no longer a constant pressure combustion, which is the basis of Diesel engine design. Either the safety valves blow or the bearings or crankshaft are damaged and sometimes broken. More often the fuel-valve needle is forced open and the valve seat and pulverizing element injured.

If the engine runs still more slowly, the oil is injected and begins to burn, but the fuel valve remains open for the same part of the stroke, and excess compressed air blows through the valve. As stated, the time element of injection remains practically constant, but when the engine runs slowly, the cam action is also slower and the valve remains open for a much longer period. This rush of compressed air actually blows out the fire in the cylinder and the engine stops.

The reverse is true at high speed. The fuel valve is not open for a time period long enough for the complete injection of the fuel, and the engine under load cannot have its speed increased, or else the output falls off. In addition to these elements tending to result in danger and stalling, the fuel consumption is enormously increased, because what appear as but slight changes from correct injection conditions will greatly affect the combustion. So much energy is handled in so small a space when a cubic centimeter of oil is injected, that it must be done with great exactness to secure the intended results.

For these reasons Professor Junkers has developed this variable injection control combined with the fuel control. The angle of advance can be regulated for each cylinder alone if desired. Further, the injection air pressure can always be immediately controlled from the operator's stand.

The two levers that controlled this engine were so arranged that the fuel and air for starting could be either operated independently, effecting a great saving in air and allowing much greater speed of reversing in the hands of a skilled operator; or interlocked, avoiding dangerous conditions when operated by an unskilled man. Reversing could be accomplished in from five to six seconds. This engine was started 96 times on an air supply of 19.5 cu. ft. originally at 85 atm. (1210 lb. per sq. in.) pressure.

The pistons are not water-cooled. They have, however, a special self-contained cooling device, which prevents the temperature of the piston head from becoming excessive. A piston or cylinder was never cracked in my year's experience with this engine.

DETAILS OF 1000-HP. STATIONARY ENGINE

The stationary engine, Fig. 1, was of the two-cylinder horizontal tandem direct-reversible type, giving 1000 hp. at 180 r.p.m. It ran successfully, however, at speeds from 25 to 220 r.p.m. The pistons were water-cooled. The cylinders were 450-mm. bore (17.8 in.), and 900-mm. stroke (35.6 in.). The normal mean effective pressure was 10 atm. (147 lb. per sq. in.), and the overload, 14 atm. (207 lb. per sq. in.). The air compressor was of the four-stage type. This engine was direct-connected to a Junkers hydraulic dynamometer for test purposes.

The engine was built especially for experiments in the development of high-power marine engines for war vessels, in which it is desirable to have all machinery below the water line.

In the five years that this engine has been running, trouble due to unequal wear has not appeared, and the cylinders have not been changed. In spite of the fact that this engine has an excessively heavy bedplate, that the flywheel is twice as heavy as is necessary for marine work, and also that it is a slow speed machine (180 r.p.m.), the weight is but 64 kg. (141 lb.) per b.hp. with the flywheel included.

Maneuvering the Large Engine

The large engine was started by air at a pressure of about 40 atm. (590 lb. per sq. in.). Because it had only two cylinders, barring over was necessary until an air starting-valve was brought into action. Then the main air tank was opened, and the starting lever drawn back, bringing the cams into operation. When the engine had attained 100 to 120 r.p.m. (in about 4 sec.) the fuel was turned on by a handwheel at the operator's right and the starting lever allowed to return. Ignition followed immediately and the engine was up to speed in about 3 sec. The injection air was turned on before starting and was regulated, when necessary, by a valve at the side of the fuel control. The air compressor was also regulated from the same point.

Reversing was accomplished by first cutting off the fuel, then throwing over a lever reversing the cam action and pulling back the starting air lever. This admitted air to the cylinders on the compression stroke and stopped the engine in one or two revolutions. The safety valves relieved excessive pressure. The starting lever was merely held back until the engine began to turn over in the reverse direction, when it was released and the fuel turned on again. The time required was about 15 seconds.

Its fuel consumption at normal load is 176 gm. per b.hp. per hr., referred to oil of 10,000 cal. per kg. This

is equivalent to 0.387 lb. per b.hp. per hr., referred to oil of 18,000 B.t.u. per lb., or 0.366 lb. per b.hp. per hr., referred to oil of 19,000 B.t.u. per lb. The engine had scavenging pumps and an air compressor 50 per cent larger than necessary to take care of overload.

Advantages of Double-Piston Construction

Perfect balance of moving parts is possible with the double-piston engine. This is of immense value in airplane and high-speed automobile engines.

The double-piston engine works best on the heavier (cheaper) fuels. For the airplane and automobile the compression is somewhat reduced so that kerosene is an ideal fuel. In view of the present cost of gasoline this point requires no emphasis.

It is a two-stroke cycle engine with the full double output of a four-stroke cycle engine, not with 1.5 to 1.7 times the output for the same piston displacement. Further the Junkers engine has a mean effective pressure of 150 lb. per sq. in. Three times the output of a four-stroke cycle engine of the same displacement can be expected.

The fuel consumption is the lowest possible, which means greater range for the same amount of fuel than is possible with the present types of engines. This is of great importance in aviation.

This engine has but one valve for each cylinder and no electric or other ignition system, the heat of the compressed air being more than sufficient. An overload of 50 per cent is possible.

Objections to Double Piston

The double-piston engine is criticized because of the so-called multiplicity of parts. At first the mechanism connecting the upper piston to the crankshaft was made rigid, and the side rods expanded unequally, throwing the pistons out of line. This connection is now flexible and never during my observation did it give any trouble or require any attention.

The assembly of these parts can be of the least careful kind and still no trouble will appear as the members are the simplest form of linkage, joints being all of the pin type (without bushings). The yoke is permitted to rock in the piston. There are three pin joints between the yoke-end and the crankshaft. The side rods are free to expand or contract. They can be set one or two inches out of line and will still operate freely.

Although quite an unskilled workman at that time, I was given the job of taking out and replacing pistons so that I know this mechanism quite well. The time required for removing both pistons in the 250-hp. marine engine was about 15 min. There is in reality only an extremely slight motion in these joints. It is a question either of an extra piston and the large, rugged and foolproof connection necessary or of a cylinder head and the multiplicity of comparatively delicate valves and valve-operating gear.

In the four-stroke cycle engine the cylinder head is not so troublesome as formerly, but in the two-stroke cycle engine it is not so far advanced as to be called entirely reliable. The valve question need not be enlarged upon, for it is evident that the parts are far greater in number and that the assembly requires the highest degree of accuracy.

Output for Different Cycles

Two-stroke cycle single-piston engines are built with only one valve (the fuel valve), but not one can show good scavenging, the output being only from 1.5 to 1.7 times

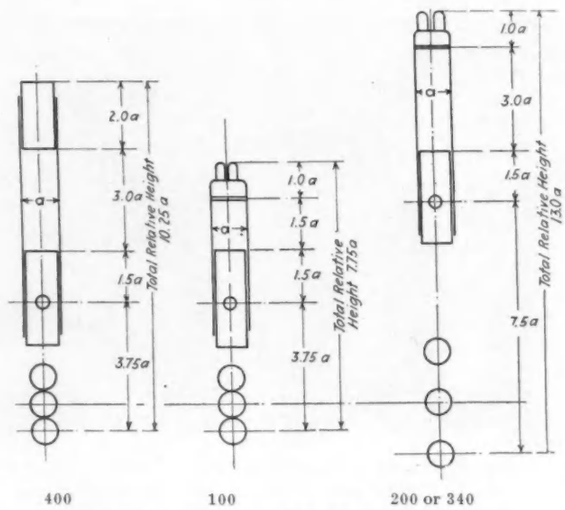


Fig. 6—Relative Engine Heights and Outputs

that of a four-stroke cycle engine of the same piston displacement per unit of time. The double-piston engine on the other hand gives four times the power of a four-stroke cycle engine of the same bore, stroke and speed.

Given a certain cylinder bore, crank-throw and speed, the outputs of four-stroke cycle, two-stroke cycle and two-stroke cycle double piston engines are as 1, 1.5 and 4. The double-piston engine attains the same or a higher mean effective pressure and a better fuel consumption than one of the four-stroke cycle type. Its piston displacement for the same crank-throw is double that of a four-stroke cycle, because the two pistons each have the same crank-throw, and its power impulses come twice as often. Hence the output is four times as great.

Comparison of Height and Output

It may be said that the double-piston engine is much higher than the single-piston engine. Assume roughly as design proportions: Bore of both engines, a; stroke, 1.5 a; connecting-rod to crank, 1 to 5; wristpin to piston head, 1.5 a; height of cylinder head, a.

From Fig. 6 it will be seen that the single-piston engine is 25 per cent shorter than the double-piston engine for the same bore and crankshaft, but with only one-fourth the output. But they can be compared better if the same piston displacement per unit of time is taken (same bore, stroke and revolutions per minute). Assuming the same design proportions as before, the double-piston engine is seen to be 21 per cent shorter than the single-piston engine for *twice* the output if the single-piston engine operates on the four-stroke cycle and for about 20 per cent greater output if the single-piston engine operates on the two-stroke cycle.

To draw a practical conclusion from this, consider engines of the same height and compare the outputs. Assume a stroke to bore ratio in a Diesel engine of 1 to 1.5 and a piston speed of 5 m. (16.4 ft.) per sec. and a mean effective pressure of 5 atm. (74 lb. per sq. in.). A Junkers engine of the same height can have a stroke to bore ratio of 1 to 2 and has therefore a higher relative piston speed with the same revolutions per minute, since the stroke is divided between two pistons. The piston speed is actually 3.5 m. (11.5 ft.) per sec. and relatively 7 m. per second.

Also assume the same mean effective pressure for both engines, although that of the Junkers engine is

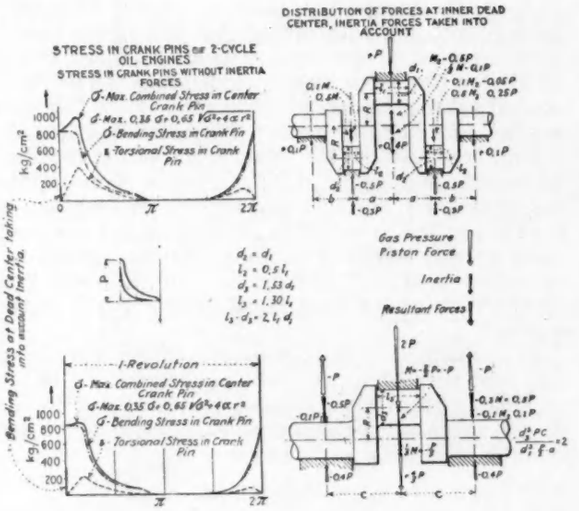

STRESS IN CRANK PINS OF 2-CYCLE OIL ENGINES
STRESS IN CRANK PINS WITHOUT INERTIA FORCES
DISTRIBUTION OF FORCES AT INNER DEAD CENTER, INERTIA FORCES TAKEN INTO ACCOUNT
Gas Pressure
Piston Force
Inertia
Resultant Forces
1-Revolution
Bending Stress at Dead Center taking into account Inertia.

FIG. 7—COMPARISON OF SINGLE AND THREE-THROW CRANKSHAFTS

higher in practice. Then the output of the two-stroke cycle Diesel is

$$hp_e = \frac{\pi\, d^2 \times 5 \times 5}{4 \times 2 \times 75} = 0.167\, \frac{\pi\, d^2}{4}$$

and the output of the Junkers is

$$hp_e = \frac{\pi\, d^2 \times 2 \times 3.5 \times 5}{4 \times 2 \times 75} = 0.243\, \frac{\pi\, d^2}{4}$$

or 1.4 times the output of the two-stroke cycle engine and 2.8 the output of the four-stroke cycle engine, assuming the same mean effective pressures.

This fact of lower height for the same output or greater output for the same height is of great importance at present with regard to the submarine.

Three-Throw Crankshaft

The three-throw crankshaft is often criticized because of its length. Let us think a moment before dismissing the three-throw shaft as inferior to the single-throw shaft. The main bearings are relieved of load in the three-throw shaft. The bending moment (the determining factor in shaft design) is but three-fourths that of a single-throw shaft.

In Fig. 7 a three-throw shaft is compared with a single-throw shaft for the same output, crank circle and crankpins and same bending stresses and surface pressures at dead center. The output of a four-stroke cycle engine using the same shaft would be but half as much.

In general the three-throw shaft is about 1.15 to 1.25 times as long and about one-half as heavy as a single-throw shaft for the same output on a two-stroke cycle engine and for half the output on a four-stroke cycle engine. This matter of weight is of importance on account of the present high cost of shafts. The flexibility of this shaft and the fact that the main bearings are relieved of load is exceedingly important since a greater portion of crankshaft breakages are due to the main bearings being out of line. In the Junkers engine the main bearings have a spherical support.

Distribution of Work

It is generally desirable to use the two-stroke cycle if the difficulties of loss of work in scavenging and troubles in constructing cylinder head and scavenging pumps can be avoided. The single-piston two-stroke cycle engine however is almost as large volumetrically as the four-stroke cycle unit of the same output. Its output is 1.5 to 1.7 that of the four-stroke cycle of same piston displacement per time unit, owing to the lower thermal efficiency and loss of work in the scavenging pumps.

The saving in scavenging work is due to the excellent conditions in the double-piston engine, requiring low pressure and securing a charge of clean cool air in the cylinder with only 1.1 times the cylinder volume of scavenging air. A charge of clean cold air is essential. An increase of 75 deg. cent. (135 deg. fahr.) in the temperature of the scavenging air means a loss in output of 25 per cent.

The overall mechanical efficiency of the engine, as taken from reports of tests made in Aachen last year, is from 72.5 to 73.5 per cent.

Author's Conclusion

I believe the double-piston engine to be mechanically and thermo-dynamically the best construction. The idea of reducing the heat outflow during the initial part of the cycle has proved itself invaluable. The advantage of mechanical balance and perfect scavenging (better than in the four-stroke cycle engine) is not easily to be measured. The high mean effective pressure, low fuel consumption, and the high output per unit piston displacement are obtained partly through perfect scavenging.

THE DISCUSSION

HENRI G. CHATAIN:—What sort of a self-contained cooling device was used with the pistons?

P. L. SCOTT:—The disadvantage of external connection to the piston is very evident. Up to this time there has always been a system of piping that connects the piston to some stationary source of cooling liquid. In the Junkers engine this cooling liquid is carried solely by and is circulated inside of the piston. The piston and the cylinder are so constructed that the heat is transferred from the head of the piston to the base and from there to the base of the cylinder. It seems to work perfectly.

C. H. JOHN:—About two and a half years ago we built an engine of the Junkers type and are running it very successfully today. Mr. Scott's point as to variable speed came to me as something new, but I believe it is well taken. We have throttled our engine down to from 200 to 500 r.p.m.

W. S. HOWARD:—What manner of oiling and kind of oil are used?

P. L. SCOTT:—The cylinders are oiled by a special oil, the characteristics of which I do not know. It was extremely heavy and thick, but bore the heat without carbonizing in the slightest degree, although it became very thin. This system was entirely separate from the other oiling systems in the engine. Each piston received oil from two pipes. The bearings were oiled through a hollow crankshaft under a pressure of about 10 lb. per sq. in. The guides on the side-rods were oiled by hand. They required little oil, only occasional attention from the oiler being necessary.

Possibilities of Semi-Diesel Types

L. G. NILSON:—Mr. Chatain has had so much personal experience with oil engines in general that I wish he would give us his personal opinion of the so-called semi-Diesels. The term "semi-Diesel" is more or less of a misnomer, so in order to make it clear I will refer to engines for instance, the Bolinders or the Mietz and

Weiss, which are similar in construction to the ordinary two-stroke cycle gasoline engine, taking the air through the crankcase, but are built more substantially and usually have hot-bulb ignition, fuel-oil injection and about 180 lb. compression.

HENRI L. CHATAIN:—The semi-Diesel engine does not have the possibilities of the high-compression engine. We made an extensive investigation throughout Europe of all the different engines, and concluded that the high-compression oil engine possessed the greatest advantages.

HERBERT CHASE:—Mr. Dumuth has had some experience in the operation of Diesel engines. I would like to know what the average opinion of the seagoing man is as to the practicability of the Diesel engine.

MR. DUMUTH:—The average sea-going man is a little afraid of the Diesel engine. It is a noisy, dirty and inflexible machine. If with the marine engine, the engineer wants 50 per cent more power he knows when he can get it without any trouble, and he is sure of it. With the oil engine of today he is not. In maneuvering especially the Diesel engine is an unknown quantity until after it is tried out, and then no two of them are alike.

CHARLES B. KING:—What is the size of the cylinders and the weight per horsepower or the horsepower per cubic inch for the 200-hp. engine?

P. L. SCOTT:—I said that I had seen the 200-hp. aeroplane engine. The engine, however, weighs about 3½ lb. per hp. I cannot give the bore and stroke accurately.

JOSEPH VAN BLERKE:—Practically all of my time has been put on high-speed gasoline engines, although I have had some experience with using kerosene. When we started to use kerosene the operation was successful down to about 75 per cent of the full load. We have sent several engines with kerosene carbureters abroad.

We stopped selling them in this country because the difference in the price of gasoline and kerosene is not sufficient to make it worth while to operate with the latter. Naturally when the engine is throttled down it should be run on gasoline, but the operators are too lazy to shift from kerosene to gasoline so we decided to stop selling them in this country. I understand they are very successful abroad as they shift at below seventy-five per cent of full load. We use two carbureters, one for kerosene and one for gasoline. Hot air is supplied from the hot-air exhaust manifold.

When the price of gasoline becomes higher, the operators will be a little more careful, and we will get better success with the kerosene than we are today. Now we are not careful enough, and the result is that when the engine is throttled down the base fills up with kerosene and ruins the engine.

A. B. BROWNE:—The indicator cards that have been shown reproduce with remarkable fidelity the card of the theoretical cycle. In most cards of the Diesel engine the admission line drops rapidly, indicating failure to realize theoretical combustion temperatures. Such is apparently not the case in these cards. The admission line is horizontal, practically to the point of cut-off, indicating high combustion efficiency. This is further demonstrated by the remarkably low fuel consumption of less than 0.4 lb. per hp. per hr. It would be interesting to know just how much of this efficiency is due to the exceptionally high pressures used and how much is to be credited to the peculiarities of the mechanical design in this particular engine.

P. L. SCOTT:—It is only because of the mechanical design that such high pressures can be used. I think that no single-piston Diesel engine would attempt to use 700 lb. per sq. in. compression, because the cylinder and the cylinder head could not stand it.

Increasing Normal Load

HERBERT CHASE:—It seems to me that a gas engine of the injection type is running at full load when the amount of fuel injected is sufficient to use up all the air. How can the normal load be increased to what is called 50 per cent overload?

P. L. SCOTT:—The method of overloading the Junkers engine is by throttling the exhaust so that the back pressure is raised, the density of the air in the cylinder being increased. The amount of oxygen is, of course, increased and more oil can be burned in the cylinders. In most designs it is possible by this method to overload the engine up to 50 per cent. The scavenging pumps are built to take care of the excess air used in this overloading. A larger crankshaft is required than would be necessary if the overload was kept down to about 5 per cent. However, the crankshaft of the Junkers engine is usually smaller by one-half than that of a single-piston engine of the same output, so that the three-throw crankshaft can be made large enough for overloading and still remain commercially profitable.

HERBERT CHASE:—How does the economy of the Junkers engine vary with the load? In the constant-volume cycle the efficiency falls off rapidly with the load, but this is not true theoretically with the constant-pressure cycle.

P. L. SCOTT:—The fuel consumption increases rapidly with the load. At one-half load it is about twenty-five per cent greater than at normal load. At overload it is also higher by from five to fifteen per cent. The remarkable high efficiency of 48 per cent can be obtained with this engine.

I—Treatment and Selection of Steel

THIS paper, which was presented at a meeting of the Indiana Section of the Society, will be published in two parts. Part I takes up the properties and determination of the critical temperatures of different steels, the effect of mechanical working on the crystalline structure of ingots and various methods of selecting steel. Part II, which will appear later in THE JOURNAL, covers the spark-test method of steel selection and the subject of heat-treatment.

By JOHN F. KELLER* *(Non-Member)*

Illustrated with CHARTS AND PHOTOGRAPHS

DURING the past few years my work has been to collect certain information concerning the selection and treatment of steel and to organize it so concisely and clearly that the engineering student in the short time of two or three lecture periods has a fairly definite understanding of the fundamental theory of the subject.

In preparing these courses I found that a great deal had been written about steel but all of it seemed to have the common fault of being written in a highly scientific style, thus making it difficult for the engineer to obtain a concrete "picture" of the ideas involved. It is my purpose in this paper to introduce charts and drawings that will possibly render the subject matter more comprehensible.

The metallurgist tells us that the greatest efficiency of steel is developed only when it is uniformly heated to just above the highest point of its "critical range," then treated according to the requirements of the material. Let us endeavor to obtain a concrete idea of this. In general, substances when they are caused to change their state, do so accompanied by a corresponding absorption or emission of heat that does not manifest itself in a change of temperature. This change can be physical, such as that of the melting of ice or the boiling of water, or it can be a change in the molecular structure (allotropic change) without an external physical change.

These changes take place at definite temperatures, to which the steel must be heated in order to obtain the highest efficiency; it is therefore extremely important to determine the temperatures accurately and to understand what takes place and what gives the efficiencies. In order to illustrate a few of the methods used in determining the temperatures and also the effect of the presence of carbon upon the location of the highest point in the range we will refer to Fig. 1.

If iron or low carbon steel is allowed to cool from a high temperature, three allotropic changes take place. They are known as the Gamma (γ) Ar_3, which occurs at about 1650 deg. fahr.; the Beta (β) Ar_2 change at 1450 deg. fahr., and the Alpha (α) Ar_1 change at 1385 deg. fahr. When carbon is added the Ar_2 point is lowered proportionately to the increase, until the carbon content is 0.85 per cent, when all three points are merged into one, known as the recalescence point, and indicated by $Ar_{3\text{-}2\text{-}1}$ on cooling curve C.

These changes occur in the reverse order on heating as is indicated by following the line *D* (located in the ferrite section) for iron or low carbon steel, and by the line *E* for high carbon steel. From this chart the critical temperature of a given steel can be found by projecting the percentage point vertically onto the curve *A*, which is a locus of critical temperature points. The temperature reading on the ordinate that corresponds to the point is the critical temperature of the material. To check this point experimentally it is only necessary to heat a sample of the material to the temperature indicated, quench and fracture. If upon examination the granular structure is very fine it will prove that the temperature to which the steel was heated and quenched was correct. To illustrate, if the iron represented in Fig. 1 in the ferrite section be gradually heated it can be noticed by following the line *D*, that as the temperature increases no change in the crystalline structure takes place until the point Ac_3 is reached and here the "grain size" becomes very fine. If carbon tool steel, represented in Fig. 1, is heated gradually, as indicated by the line *E* structural and carbon changes occur at the decalescence point or $Ac_{1\text{-}2\text{-}3}$ indicated at *b* or that portion of Fig. 1 just above the decalescence point. This illustrates the effect of carbon on iron in lowering the critical temperature and also illustrates the important point of uniformly heating the steel to that temperature in order that the molecular or carbon change can take place.

The determination of the critical temperature in commercial practice is the next and very important point. The crystalline structure is the smallest at the critical temperature and becomes larger again as the temperature increases above this point. It is necessary to get the steel to a sufficiently high temperature, but it is also just as important not to get it any hotter than necessary. (The effect of overheating will be explained later.) To the trade this temperature is indicated by a light or dark cherry-red color, depending on the intensity of the light.

Sight and health are then important factors in this method, and it is safe to state that 90 per cent of critical-temperature determinations are made by the "trained-eye" method. For steel with carbon content above 0.45 per cent, the magnetic test is valuable

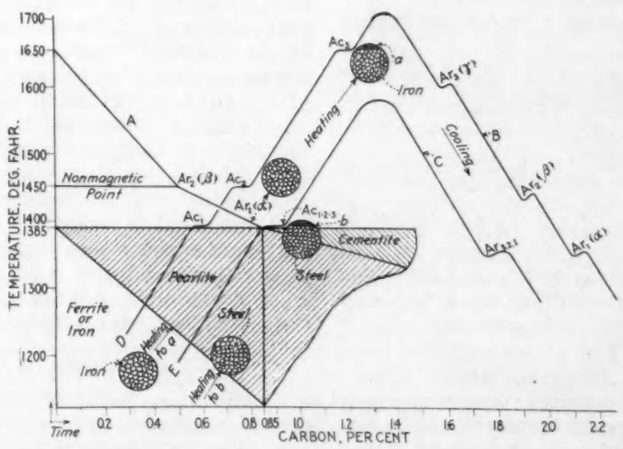


FIG. 1—EFFECT OF CARBON ON CRITICAL TEMPERATURES OF STEEL

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because iron and steel lose their magnetic properties if heated to the Ac_2 heating point, indicated on curve *D*. This point is lowered with an increase of carbon, as indicated by the cooling curve *A*, so we find that tool steel is non-magnetic at the $Ac_{1\text{-}2\text{-}3}$ point. Hence for steel with above 0.45 per cent carbon the magnetic test can be used.

The recalescence point is most satisfactorily determined as follows: The block of steel is heated above the highest point of the critical range and allowed to cool in the furnace; a temperature reading is taken about every ten seconds. The temperature will fall constantly until it reaches the recalescence point, when the temperature will remain stationary for a short time. This is due to the "evolving" of the heat "absorbed" in the molecular change that occurred at the "decalescence" point on heating. When the metal becomes stable the temperature will again fall constantly to atmospheric temperature. If a time-temperature curve is plotted from the data collected it will appear similar to cooling curve *B* for low carbon steel and to *C* for tool steel.

In the absence of this apparatus the fracture test can be used, as follows: Select a sample of the stock to be drawn, nick with a chisel at points 2 in. apart and cut pieces 2 in. long. With the nicked portion in the center, mark each block with a stencil at 10, 20 or 30 deg. intervals, beginning below the lowest point of the critical range and above Ac_1. Heat each block if possible in contact with hot end of the thermocouple. When heated to the proper temperature remove, quench in water, dry and fracture. The finest grain will indicate the approximate decalescence point. If this test is carried out with some degree of accuracy much can be learned from the operation.

It thus appears that carbon has considerable influence upon the location of the "decalescence" or "recalescence" points of steel. It also has many other important effects. Its strong chemical affinity for iron and its dominating influence upon the physical properties give it paramount importance in any problem relating to steel.

Although of itself carbon does not possess strength or hardness (except in the diamond form), it confers both of these properties when present in iron. Indeed all iron contains at least a trace of carbon, and as previously noted this element is a most important constituent of steel. Its further effect is to decrease ductility and malleability and lower the steel's magnetism and electrical conductivity. The percentage of carbon is always a factor to be reckoned with; when the contents of other elements are increased or decreased, its influence is manifested in manufacture, heat-treatment, an din the quality of finished product.

To emphasize the above statement the following table is taken from "Souveur's Metallography of Iron and Steel":

Constituent	Strength, Lb. per Sq. In.	Elongation, Per Cent.	Hardness	Hardening Power
Ferrite	40,000±	40	Soft	None
Pearlite	125,000±	10	Hard	Maximum
Cementite	125,000?	10	Hard	Maximum

The presence of carbon in iron not only affects the hardness and strength of the resultant steel but also affects the value of the critical temperature. Fig. 2 gives some conception of the effect of carbon when combined with iron. The sector marked "ferrite" (mineralogical name for iron) represents commercial iron free from carbon. The dark spots represent slag while the grain represents the granular or crystalline structure somewhat enlarged. By referring to the table it may be noticed that such iron has a low tensile strength, is soft and ductile, with no hardening power; that is, if heated to a high temperature and then quenched in water it will show no appreciable hardness.

With the addition of carbon to iron, the strength, hardness, brittleness and hardening power increase while elongation, ductility, and weldability decrease as shown

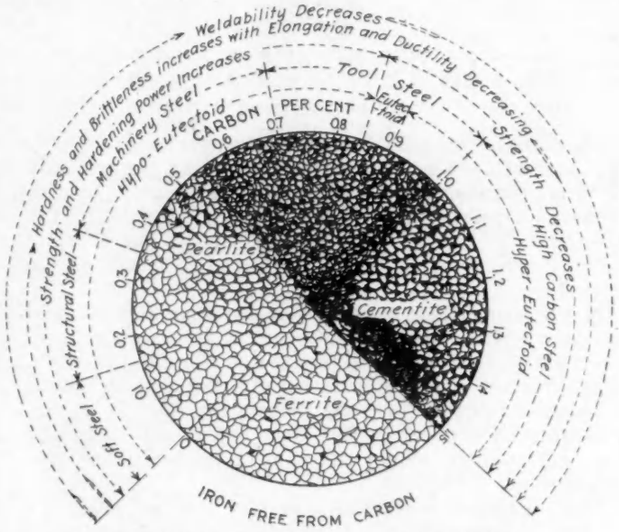


FIG. 2—EFFECT OF CARBON WHEN COMBINED WITH IRON

in the sector marked "pearlite" (so called because of its resemblance to mother-of-pearl when examined through a high-power microscope), indicated by the darkening and reduction of grain size to the "eutectoid" or carbon content of 0.85 per cent. This point is also known as the "eutectic" or saturated solid solution of iron and carbon.

When this metal is in an annealed state it is all pearlite and it is this that imparts to the metal the maximum strength and hardening power when properly manipulated by heat-treatment. On the other hand, if the metal contains less than the eutectoid proportion of carbon (hypo-eutectoid steel) only part of the iron is combined with the carbon. The strength and hardening power would then be proportional to the percentage of carbon in the iron.

The carbon in steel containing more than the eutectoid proportion (hyper-eutectoid) is known as "cementite" and since the iron is thoroughly saturated at 0.85 per cent, the surplus carbon is rejected to the boundary lines of the grains, indicated by the heavy lines surrounding the grains in the sector marked cementite. The strength of cementite as given in the table, is only about 5000 lb. per sq. in., calculated theoretically; it has no elongation, is very hard, and has no hardening power. Therefore, brittleness, elongation and strength decrease proportionately with the increase of carbon above the eutectoid, indicated in and at the right of the cementite sector.

It thus appears that carbon combined with iron is the predominant element governing the various grades of steel, depending, of course, upon their base (iron) and the method of manufacture.

PROCESSES IN MAKING STEEL

Steel can be considered as passing through three well defined stages of development.

1. Ore from the mine to the blast furnace.
2. Process through the blast furnace and onto the steel mill, bloom mill and bar mill.

3. Operations that largely influence and determine the steel's molecular structure; collectively known under the broad term—heat-treatment.

At the end of the second stage the iron has been highly refined, undesirable elements removed, beneficial alloys added in some cases until the product is known as "commercial" steel and is furnished to industrial plants under the name of soft steel, structural steel, machinery steel, carbon tool steel, high carbon tool steel, alloy structural steel, self-hardening tool steel, high speed steel and "steelite."

The tool steels are of considerable importance in our industrial development, so that a short description of the method of manufacture will not be out of place. These steels are known as crucible steels. The name is derived, as is also that of the Bessemer and open-hearth steels, from the process by which it is made. This steel, instead of being made from the pig iron, as are the others, has muck-bar or wrought iron for its base. For the more expensive grades and higher physical properties required for tool and alloy steels, Swedish iron is used as the base. The base, be it wrought iron, Swedish iron or scrap steel, is cut up into small sections, 90 to 100 lb. of which is placed in the crucible. Charcoal, pig iron or other carbonizing elements are added in proper proportion on top of the crucible. These carbonizing elements are used to impart hardening power and other desirable characteristics to the steel. In the case of special steel, alloying elements in combinations, such as metallic nickel, manganese, tungsten, chromium, vanadium, and molybdenum are placed in the crucible, in proportion to the quality and grade of steel required.

These elements impart characteristics, such as hardening power, wearing and cutting properties, to the steel, and in certain combinations produce such qualities as unusual strength, toughness, resistance to shock and vibrations. Whatever physical requirements are wanted in the steel being produced are obtained by adding the necessary alloying elements to the base. The main factor in the process is the melting rather than the converting, as in the other methods, so that whatever elements are placed in the crucible are thoroughly mixed in the poured ingot of steel, except the slag which is swabbed off.

Before the crucibles are placed in the furnace, they are covered over with lids, made of sawed-off bottoms of old crucibles, in order to prevent the impurities of the combustion from coming in contact with the contents. They are then placed in the furnace, which may hold as many as 36 pots. The melting takes on an average two to three hours. Examination of the charge is made by removing the cover to make sure it is entirely melted, after which it is kept in the furnace a sufficient length of time in order that it may seem "dead"; that is, so that it will pour quietly without the evolution of gas. If poured before it is "dead" the ingots will contain some occluded gas, while on the other hand, if the "killing" time is too long, the ingot will be solid and the steel will be hard and brittle and weak.

When in the judgment of the melter the steel has been properly "killed," which usually takes about three and one-half or four hours, this including the melting time, the crucibles are removed from the fire. The slag is swabbed with a ball of cold slag on the end of an iron rod, similar to the method of removing slag from a crucible in foundry practice. It is then poured into ingot molds which will hold the contents of the crucible. The metal must be poured into this in a continuous stream and with great care, so that the stream is not broken or does not touch the sides during the pouring. Carelessness in this operation will produce pin holes and scabs in the ingot, which can not be closed, especially in hard or unweldable steels. In pouring large ingots, the pots are emptied into a ladle that holds the contents of a large number of crucibles. As the pots vary widely in chemical composition, this method insures a thorough mixture of the steel, requiring but one complete determination and analysis for that heat, which is numbered and recorded by some symbol on the finished product.

Grading the Ingots

The quality of steel depends upon the method of manufacture, the chemical composition of the base material, and the method of handling and treating when shaped, to be hereinafter described. Even when of almost identical composition crucible and electric steels take first rank for quality, open-hearth and Bessemer coming next in the order named. The quality of crucible steel depends upon the nature of the raw material entering into the crucible mixture. In general the lower the percentage of sulphur and phosphorus, the better the quality of the steel, and the higher the carbon, the more pernicious is the effect of these undesirable elements. The degree of carbonization is generally referred to as "temper" of an ingot.

In a works making hundreds or thousands of small ingots per day, it would be manifestly impossible to analyze each ingot for carbon. Fortunately, this is not necessary as a small difference in carbon, sulphur and phosphorus elements so changes the fracture, or crystallization of the ingot, that the skilled inspector can detect with the eye differences in carbon, within one-tenth of one per cent. The ingots, after they are cooled, are therefore always graded by the appearance of the fracture made by breaking off the upper part, which contains the pipe. The ingots are all put away in a pile with others of like appearance in fracture. Chemical analyses are usually made of a few of the ingots in such piles, particularly so of the better qualities of structural tool steel.

The presence of a large amount of tungsten, chromium, molybdenum, and other alloying metals interferes with or precludes entirely the estimation of carbon with the eye. Therefore as the percentage of carbon is the most important factor in determining the suitability of any steel for a given purpose, it is necessary chemically to analyze alloy steels in order to determine their percentage of carbon and other elements.

Crystallization of Steel Ingots

Iron and steel when in the solid state are of crystalline nature. The development of these crystals as the metal cools from the liquid state depends upon two factors: First, the length of time required for the ingot to cool to the lowest point in the critical range; and second, the impurities in the metal, particularly phosphorus or sulphur, both of which seem to act as catalytic agents and tend to increase the rate of crystal growth in proportion to their percentage in the metal. Most other alloying elements, such as manganese, nickel, chromium and vanadium, tend to retard this rate of growth to a greater or less degree. Fig. 3 is a diagrammatic representation of the nature of the formation of the crystalline structure in an ingot of steel.

The nuclei, represented by small dots in the figure marked "liquid steel," attract surrounding crystal matter in proportion to the above mentioned elements in the metal, which may accelerate or retard crystallization, and to the length of time the metal retains heat above the

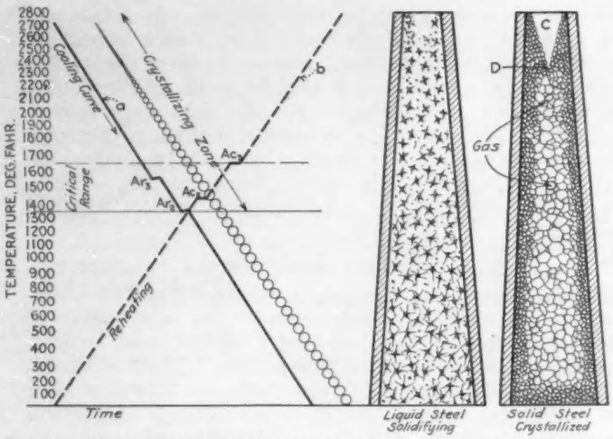


FIG. 3—FORMATION OF THE CRYSTALLINE STRUCTURE OF STEEL INGOTS

lowest point of the "critical range," indicated by the line of circles parallel to the cooling curve. The circles also represent the relative size of the crystals. Therefore, the longer the metal remains in the crystallizing zone above the lowest point of the "critical range," the greater the crystal development proportional to time and elements in the metal indicated by the "solid steel" ingot (Fig. 3). The portion close to the mold solidifies and cools first, while the center of the ingot requires time to cool. Therefore the migration of the crystals is not prevented by the rigidity of the metal. The pipe end of the ingot, marked *C*, is, of course, defective, and should be cut off along the line *D*. Failure to do so will cause a serious defect in that portion of the finished product. Blowholes or gas pockets near the edges will cause seams, especially so in unweldable steels. In the lower grades of steel, the solidified ingot is placed in the furnace or soaking pit in order that the ingot can be uniformly heated to a semi-plastic state; first, to unite by welding all weldable imperfections or defects in the steel; and second, the softer and more plastic the metal the less power required to move a given mass of material.

We now have the ingot in an indifferent crystalline state. Let us observe the effect of working the metal, such as of reheating, rolling, hammering or squeezing. The reduction of the ingot has three objects in view: The formation into desired commercial shapes; elimination of defects in the case of weldable steel; and the reduction of the large-size crystals that were formed by excessive heating and slow cooling.

Fig. 4 represents the effect of reheating, soaking and rolling upon the crystalline structure of steel. The line of circles parallel to the heating and cooling curve represents the relative size of the grains or crystals.

The reheating curve shows that the size of the crystals remains constant until Ac_3, the highest point of the "critical range," is reached, when a molecular change occurs, reducing the crystals to their normal size. The migration of crystals begins at this point in the metal and continues to develop in proportion to its composition and to the length of time the metal remains in the crystallizing zone. Continued rolling of the steel from a high temperature disturbs and prevents coalescence or migration of the crystals, indicated by the decrease in the size of the circles along the cooling curve and in the crystallizing zone to Ar_3 or Ar_2, or the lowest point of the "critical range." This can also be observed in the figure "Rolling Ingot," in which the portion of the ingot under compression between the rolls shows the very small grains or crystals, while on the end of the rolled bar, the crystals again coalesce in proportion to the temperature above Ar_2.

Therefore, if the steel is continuously rolled or hammered to the point Ar_2, the grain or crystal will be about normal size, while on the other hand, if work ceases above the point indicated, the structure will depend on the temperature at which work ceases and on the elements contained in the metal being worked. It is manifestly impossible to continue to roll or to hammer large sections of steel to the temperature indicated, owing to the enormous amount of power required to cause the steel to flow under pressure, while on the other hand small sections requiring less power can be worked to the temperature desired, and sometimes below that point. This is one of the reasons for the occurrence of fine grains or crystals in small bars of commercial shapes.

This is about the regular procedure followed in the manufacture of the lower grades of commercial shapes, with the exception that the bars are sheared to convenient length and the smaller sizes tied up into bundles ready for shipment, with no identification mark whatever.

In the better quality of structural and tool steels the ingots are allowed to become cold, and then graded by the appearance of the fracture or according to the results of the chemical analysis.

When the ingots are thus graded, they are placed in a furnace and reheated uniformly to the temperature desired. The defective part or pipe is cut off and discarded. The ingot is then rolled or hammered and again rolled for finish and uniformity of size. Fig. 5 illustrates the effect of shear or compression, both in rolling and hammering. The hot ingot (*a*) is moved along the table to the shear, where the pipe-end *C* is sheared off. The ingot (*b*) is then passed on and through the rolls *E* and *F*, which are directly opposite. Therefore compression takes place with the metal flowing along the horizontal. If all of the pipe-end *C* has not been removed, the defect will remain in the center of the finished product, even if drawn to a fine wire.

The inner surfaces of *C* are usually covered with a thick coating of oxide, which prevents welding of the defect. It is also a nucleus for internal seams caused from shear action in forging, especially in forging polygons and rounds. Deep-seated blow-holes or gas pockets will also have the same effect unless they are welded, a possibility in weldable steel, but a practical impossibility in some of the hard and brittle unweldable

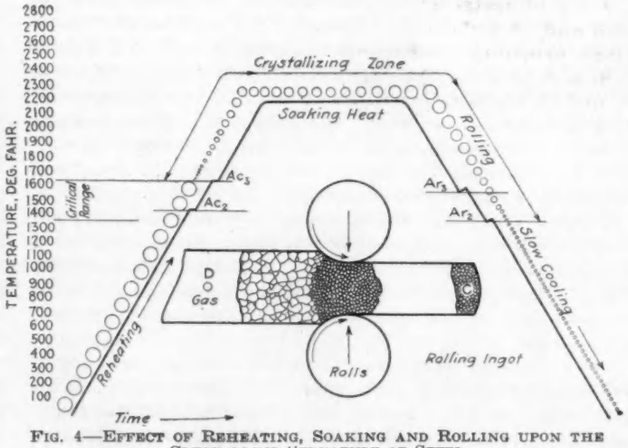


FIG. 4—EFFECT OF REHEATING, SOAKING AND ROLLING UPON THE CRYSTALLINE STRUCTURE OF STEEL

alloys or high speed tool steels, the greater portion of which are forged to shape under steam hammers or hydraulic squeezers and between flat dies. The process makes a very efficient material, providing it is handled with care and intelligence.

Effect of Hammering the Ingot

The illustrations of hammering are inserted in Fig. 5 in order to explain more fully the cause of some of the many defects in hammered stock, more especially in the brittle alloy steels and the polygon and round sections. If the hammer dies (*c*) are planed parallel and the points of contact on the metal are diametrically opposite, every particle of metal under the dies will be under compression and, if sufficiently plastic, will flow in a horizontal plane, providing the hammer is heavy enough or the force sufficient to move the entire mass indicated by the convexity of the end and sides of the bar in (*a*) and (*d*). In the cross section of (*d*) the reason for such convexity is probably that the metal is held by friction of the top and bottom dies. A light blow or light hammer will have the opposite effect, that of drawing the surface of the stock and leaving the center of the metal undisturbed, causing the end of the bar to become concave, with sharp corners on the sides. While this operation has its disadvantages in not moving the center of the metal, it has considerable advantages, as will be shown later, if used intelligently.

The next operation is one that must be given serious consideration. The stock should be turned so that the sides will form a right angle to the face of the dies—indicated at (*e*). If placed in this position, every particle of metal will again be under compression. The operation is continued in this manner with a heavy blow until the size is almost that desired. Then diminish the force of the blow in order to fill out the corners and to smooth up the surface. If there is no previous defect in the ingot, none will be caused by this operation.

On the other hand, if the metal is placed in the position as at (*f*), the metal will either slip or shear. The two points of contact are not diametrically opposite, and as force will follow the lines of least resistance, the metal will slip or roll if in a plastic state, but if the steel is slightly rigid from low temperature, or is the hard alloy or high speed, shear will undoubtedly occur. It may not be noticeable on the surface of the stock, but, nevertheless, such action takes place inside of the bar, particularly so if there is the defect *C* or *D* in the ingot.

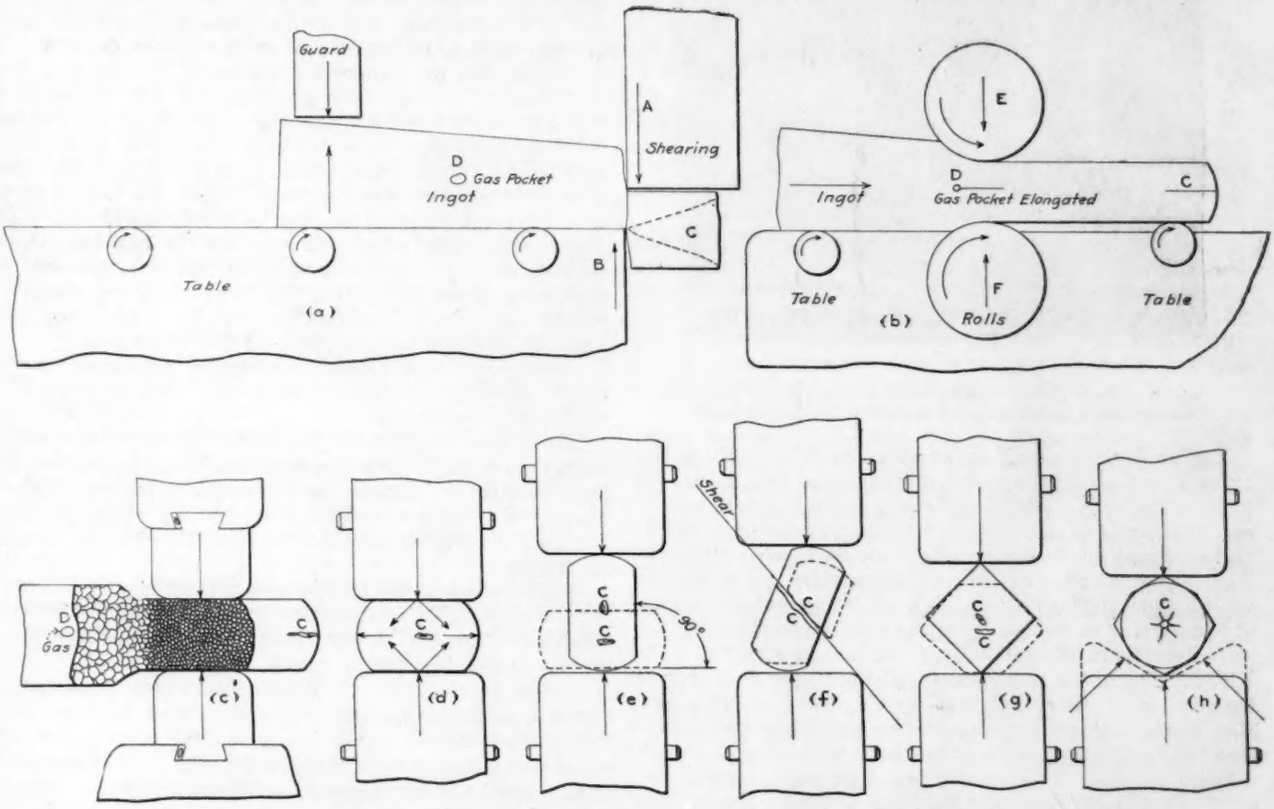
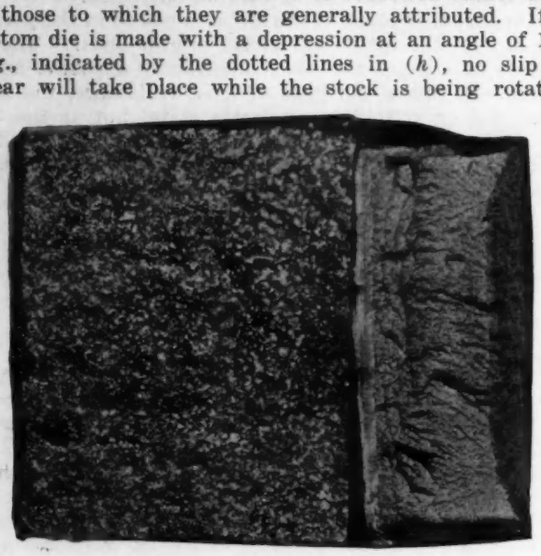


Fig. 5—Diagrammatical Illustration of the Effect of Shear and Compression in Rolling and Hammering

In drawing a polygon or round section, the same procedure as outlined in drawing a square section is followed, hard blows being used until the section is drawn slightly smaller than the square of the area of the diameter of the polygon or round section desired, when it is placed in the position indicated at (*g*). If there is no defect in the steel such as shown at *C* or *D*, compression will take place; otherwise, *C* or *D* being the lines of least resistance, the metal may slip or shear along one of them. On the other hand, if the steel has been drawn to the size suggested, it will not be necessary to use sufficient force to disturb the center, so that the slip or shear effect will be eliminated. Likewise, if a light blow is used on the round section as at (*h*) the defect that may be in the steel will not be aggravated.

The mistake usually made by the hammer operators is that they begin forming the polygon or round section from too large a square section. Therefore sufficient force must be delivered to move the entire mass in order to reduce it to the size required. Constant rotation be-

tween flat dies delivering a heavy blow will split or shear the best grade of steel ever made and many of the internal defects found in alloy and high speed steels can be traced to such a method of reduction rather than to those to which they are generally attributed. If a bottom die is made with a depression at an angle of 120 deg., indicated by the dotted lines in (*h*), no slip or shear will take place while the stock is being rotated.



(*A*) (*B*)

FIG. 6—(*A*) NATURAL APPEARANCE OF STEEL INGOT. (*B*) SAME INGOT AFTER CORRECT ROLLING AND HAMMERING

I have devoted considerable space to this phase of the subject so that the buyer of raw material will be on the lookout for such defects, especially in high priced steels, and further that the mechanic in forging the raw material shall not create such defects in the finished product. Fig. 6 represents the natural appearance of a slowly cooled, small ingot of steel. View (*b*) represents the effect of hammering or rolling upon the crystalline structure of (*a*), heretofore represented by the pen at (*d*) and (*e*), Fig. 5. The views as shown are about 15 per cent larger than full size. The small test-bar (*a*) was broken in one blow under a steam hammer (note crystalline structure). One end of this bar (*b*) was heated to a forging heat and reduced in size. The sample was hammered constantly until the temperature had dropped to about the lowest point of the "critical range," better known to the trade as a dark red heat. It was then allowed to cool slowly in the air. When cold it was nicked on one side with a cold chisel and broken under the steam hammer, requiring three heavy blows to fracture it, while the ingot required only one blow, without nicking.

The foregoing figure illustrates the effect of hammering or rolling upon the crystalline structure, if either be continued until the metal is cooled to the lowest point of the "critical range." If work ceased above that point, the grains or crystals would be proportionately larger.

Upon the final finishing heat of high quality or expensive material the metal is allowed to cool, is then inspected for defects and stamped with trademark or temper. In addition colored labels are pasted on the bars or in the medium-quality steel the ends of the bars may be painted a definite color.

Upon the receipt of such expensive material it should be stored and marked for identification in the factory. The usual method of marking is a distinct color or combination of colors, painted the full length of the bar. Great care must be taken, however, to see that the prescribed color of paint is used; otherwise this method of marking is of no value. The advantage of this system when applied intelligently is that short pieces of valuable stock will not be thrown into the scrap heap.

A system of properly marking raw material in storage and methods of selecting such stock for important machine parts and tools is of vital importance to modern shop practice.

METHODS OF SELECTING STEEL

The methods of selecting steel used by the engineer are: 1. Chemical analysis. 2. Inspection of stencil trademarks or labels. 3. Hardness test. 4. Microscopical examination. 5. Service test.

When a quantity of steel is furnished from the same heat so that all of the bar is nearly alike in composition, the chemist's problem will be that of analyzing a few bars, but if the material is from mixed heats, as it is when obtained from large storage centers, then the chemist must analyze each bar in order to arrive at an accurate conclusion. This would require considerable time and expense even when a metallurgist was employed in the plant. A commercial chemist would charge for analyzing one sample of carbon steel for the usual elements, carbon, phosphor and sulphur about $4.50. The cost of analyzing short pieces of bar stock or scrap material would therefore be prohibitive. On the other hand, the analysis of alloy steel is much more expensive.

The inspection of stencil trademarks and labels is the most dependable method of selecting steel, next to that of chemical analysis.

The Brinell and scleroscope hardening tests are used to some extent in testing the material in its normal state. Heat treatment, however, increases the hardness of steel. Therefore, we question the reliability of either method for determining the composition of the different steels accurately.

A microscopical examination is not satisfactory in determining the chemical composition of metals, but is very reliable for the last heat treatment given the metal. This system is not in general use in industrial plants.

In the service test many engineers select available material at hand and put expensive labor on the part or tool, then put it in service. If it fails it is discarded to the scrap pile or they may have it analyzed chemically or examined microscopically to determine why it failed.

The following methods of inspection or test are used by workmen in selecting steel:

1. Trade or quality stencil marks.
2. Labels pasted on the bars.
3. Bars painted different colors.
4. General shape of the material.
5. Appearance of the surface.
6. Weight, steel 2 per cent heavier.
7. Ring or tone of the metal when dropped.
8. Feeling, intuition or smell.
9. Fracture test.
10. Fire and water test.
11. Service test.
12. Spark test.

1 and 2. These are the most dependable methods except that if the steel is kept in a damp place the labels will drop off in the course of time owing to rust under the labels.

3. This method is dependable, providing, however, that a general scheme of colors be outlined for the different brands of steel, and the system is intelligently applied. In many factories extreme carelessness and indifference are prevalent in the painting of valuable stock. We found

in one factory seven distinct grades of steel painted with the same color.

4. Many workmen select steel by its general shape, for instance a hexagon section would represent screw stock, while an octagon section would indicate cold chisel steel, but this method of selecting should not be tolerated because all steel regardless of quality can be manufactured into any form or shape desired, except steelite which is cast into form.

5. Tool steels are largely selected by the appearance of the surface. If the bars are smooth and have sharp corners it is evidence to the workman of a first-class quality of steel. Without other evidence expensive labor is put upon the tool and when hardening is attempted the mistake is usually discovered. It is then discarded to the scrap heap. Smooth surface and sharp corners indicate work, hammering or rolling at low temperatures. Cold rolled stock illustrates this fact. Rough surface and round corners are caused by an iron oxide scale when the metal is laid down at high temperature. Therefore, appearance of the surface does not indicate quality or composition of the metal.

7. Many workmen, not satisfied in their examination as described in Nos. 4, 5 and 6, drop the metal on a hard floor or a heavy piece of iron. If the ring has a sharp tone it is evident, in their estimation, that the steel is of good quality. The finer the grain the more homogeneous the structure and the harder the metal, the sharper the tone. These qualities are developed by working and by heat-treating the metal at a moderately low temperature. On the other hand wrought iron will emit a dull tone owing to about 2 per cent of slag and the usual methods of working such metal at a high temperature. This method is not reliable or dependable because work and heat-treatment will affect the tones emitted when the material is struck or dropped.

8. It is surprising how many expert tool men will select metal by "intuition" and will work the tool into shape regardless of further indication in its cutting properties that the metal may be undesirable, simply because they feel that the stock is what they wanted. Their mistake is usually discovered when attempting to harden the metal or when putting it into service. It is then usually discarded to the scrap heap.

9. The fracture test does not represent thoroughly the quality of metal, but rather indicates the last heating operation to which the metal has been subjected. A fracture that has a coarse granular appearance may mean, not that the material is of inferior quality, but that it was laid down at a high heat and the crystals retained the size corresponding to that heat. There are exceptions, however, when many of the elements in alloy steels prevent or retard crystallization at high temperature. High speed steel is an illustration of this fact, showing an unusually fine grain after heating to 2250 deg. fahr. On the other hand if carbon tool steel was heated to its critical temperature and immediately quenched it would show a fine silky structure and I question the average mechanic's ability to distinguish the two metals when placed together for comparison.

10. If a small piece of carbon tool steel is heated to just above its critical temperature, about 1450 deg. fahr., known as a dark cherry red, and immediately quenched in water, it will be hard enough to resist a sharp file and when fractured should show a fine silky structure. If a low or inferior grade of carbon steel is so treated the surface may be hard enough to resist a file but the fracture will not show a fine silky structure.

11. The service test has its advantages, especially to the engineer, providing he has knowledge of the material tested. The experimental engineer in considering the choice of steels for many purposes, has before him the well-kept record of previous service tests. This information is invaluable, because the combination of successes and failures gives the empirical knowledge that completes the understanding of theory. Accurate records of the lifework of a piece of steel are the most powerful tools used by an engineer.

NATIONAL HIGHWAY SYSTEM

Now that all of the States have been equipped with State highway departments and have adopted the policy of building State systems of main through-line highways —because the Federal Aid Road Act is on the statute books—every condition is favorable for the next and crowning act, the establishment of a national system of highways. In a statement issued by the Good Roads Board of the American Automobile Association it is said that gradually the State has made itself a compelling factor in the handling of local road problems. As a logical sequence, the Federal Government, first through educational activity, and later by the financial aid provided by the Federal Aid Law, has made itself a powerful instrumentality in the working out of the State highway problems. The next logical step follows the same course which has been pursued by the State governments, namely, the broadening of Federal participation to provide for the establishment of a system of national highways.

This policy can be put into effect without disturbance of existing organizations, without providing new means of finance and with but little change in existing law. The process would logically take a course as follows:

First: The State highway departments and the Federal Office of Public Roads would make an initial selection from existing State highway systems of those highways which are of interstate importance.

Second: A system thus selected would be approved by Congress, with the requirement that Federal funds be applied only to such system on and after a specified date.

Third: The Federal Aid should be extended to maintenance as well as construction, as the National system of highways should have for all time a close relationship to the Federal Government.

Some of the States have already made plans for utilizing the aid granted by the Federal Aid Road Act on roads which could not properly be included in a national system. But this need not cause extreme conflict, as the Federal funds for the first three or four years' operation of the present act could continue to be applied as now planned. The appropriations for the first two years are already available, and considerable time necessarily must lapse before the national system could be laid out and made ready for the application of Federal funds.

In all probability the new scheme would come into effect as an extension of the Federal Aid Road Act.

Problems in Ignition Development

By H. E. RICE* (*Member of the Society*)

PENNSYLVANIA SECTION PAPER *Illustrated with* PHOTOGRAPHS

TO the man or men responsible for the design, production and sale of automobiles the ignition is but one of many technical problems, such as those of lubrication, carburetion, engine, transmission, heat radiation and frame design, together with many non-technical problems, such as body design, seating arrangement, trim, finish and comfort accessories. All of these must be balanced and weighed by the automobile designer, and he is permitted but little opportunity to delve deeply into the problems entering into any single factor in his design. For him to attempt this would be fatal to his larger responsibilities.

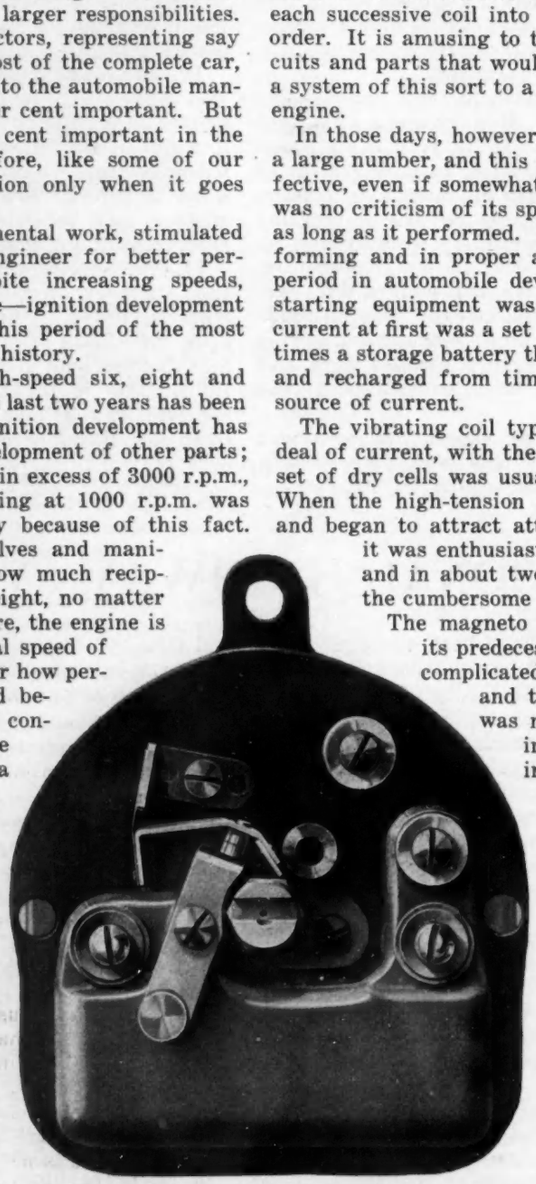
Ignition is but one of many factors, representing say one per cent or less of the total cost of the complete car, and as long as it is satisfactory, is to the automobile manufacturer or car owner but one per cent important. But ignition can be one hundred per cent important in the operation of the car, and, therefore, like some of our public officials, it attracts attention only when it goes wrong.

Thanks to competitive developmental work, stimulated by the desire of the designing engineer for better performance and lower price—despite increasing speeds, more cylinders and poorer gasoline—ignition development has more than held its own in this period of the most rapid development in engineering history.

The rapid development of high-speed six, eight and twelve-cylinder engines during the last two years has been made possible largely because ignition development has more than kept pace with the development of other parts; that we now utilize engine speeds in excess of 3000 r.p.m., when a few years ago one running at 1000 r.p.m. was considered high speed, is largely because of this fact. No matter how much better valves and manifolds are designed, no matter how much reciprocating parts are reduced in weight, no matter how much better balanced they are, the engine is limited in its speed to the critical speed of its ignition equipment. No matter how perfect the engine, its good or bad behavior depends largely on the constancy and dependability of the little spark that represents such a minute quantity of energy, and the duration of which is but a thousandth of a second.

To discuss a few of the problems involved in the simple and efficient ignition equipment now obtainable—some of the problems already solved—and a suggestion of the work yet to be done, is the object of this paper.

The first ignition used for automobile engines was of the so-called battery type. It was as much like the present-day equipment as the first curve-dash Oldsmobile was like the four, six, eight or twelve-cylinder roadster of today.



CONTACT MAKER FOR CLOSED-CIRCUIT TYPE OF BATTERY-IGNITION SYSTEM

EARLY HISTORY OF IGNITION DEVELOPMENT

The first and most commonly used ignition system consisted of an ordinary induction coil with a series vibrator arranged so as to produce a stream of sparks when the primary circuit was closed. A separate coil was connected directly to the spark-plug of each cylinder, and a commutator or low-tension distributor was used for cutting each successive coil into the circuit in the proper firing order. It is amusing to think of the complication of circuits and parts that would result from the application of a system of this sort to a modern eight or twelve-cylinder engine.

In those days, however, four cylinders were considered a large number, and this early ignition equipment was effective, even if somewhat fussy and complicated. There was no criticism of its spark heat nor of its performance, as long as it performed. The difficulty was to keep it performing and in proper adjustment. At this particular period in automobile development, electric lighting and starting equipment was undreamed of; the source of current at first was a set of ordinary dry cells, with sometimes a storage battery that was charged when off the car and recharged from time to time from an independent source of current.

The vibrating coil type of ignition consumed a great deal of current, with the result that the average life of a set of dry cells was usually only from 250 to 400 miles. When the high-tension magneto was developed abroad, and began to attract attention along in 1907 and 1908, it was enthusiastically welcomed in this country, and in about two years had practically displaced the cumbersome battery-coil vibrator system.

The magneto was unquestionably superior to its predecessor. While it was (and still is) complicated internally, it was self-contained, and the electrical part of the system was much simpler. With the vibrating coil the time element intervening between the close of the primary circuit and the production of the spark was always constant. At low speeds the engine crank might travel 20 deg, during this time element. At twice the speed it would, of course, travel twice as far, so that it was necessary to shift the spark over a wide range of advance and retard to compensate for the so-called lag, which was not present in the magneto. Also the magneto produced a single spark of greater intensity than any one of the stream of sparks produced by the vibrating-coil system.

* Sales Manager, Atwater Kent Mfg. Works.

With all of these points in its favor, the magneto was a step forward in the problem of ignition and logically became popular.

In some respects, however, the magneto did not make so good a showing as the older vibrating-coil system. For instance, at a certain minimum cranking speed the magneto ceased to generate sufficient current to jump the spark-plug gaps, while with the older battery system the stream of sparks produced in each cylinder was, if anything, hotter at low than at high speeds, and owing to the stream of sparks a sufficient amount of heat was liberated to assist somewhat in overcoming starting difficulties. As a result so-called dual-magneto systems came into use. In these the contact-making device and distributor of the magneto were used in conjunction with a vibrating coil and battery so as to effect a combination of the old system and the new.

This provided a hot spark or stream of sparks for starting and for low engine speeds, but resulted again in considerable electrical and mechanical complication. It is only just, however, that credit be given for the very satisfactory performance of the magneto at moderately high speeds and also to the excellent standard of workmanship evidenced in some of the higher grade magnetos in the last six years. For engines of limited speed range, with which no spark is required at a speed of less than 100 r.p.m., whose maximum speed does not exceed 2000 r.p.m., and whose powerplant is not electrically equipped, the magneto is a satisfactory ignition-source.

Introduction of Electrical Equipment

Almost immediately following the adoption of electrical equipment on passenger cars, the advantage of the practically constant voltage generator and battery equipment as a source of current began to attract attention.

As soon as it was possible to have confidence in the mechanical integrity of the new generator and storage battery equipment on cars, its use as an ignition source followed logically. Today out of a total of 109 manufacturers of cars, 87 use battery ignition exclusively, and 22 use magnetos, furthermore, many of the 22 use dual-magneto systems, so that they may be said to use semi-battery ignition.

The magneto fundamentally consists of a generator and of a transforming and a distributing device, for producing and distributing the ignition current. Battery ignition in its essentials consists simply of transforming and distributing devices without the generator.

On an electrically equipped car the source of current is quite independent of the engine speed. Current is available even when the engine is not running. Therefore it is not necessary to obtain a certain minimum cranking speed at which the spark will be hot enough to ignite the usual poor starting mixture. With a battery system a full sized spark is obtained, quite independent of the cranking speed, on the first quarter-turn of the engine. Owing to its practically constant-current source, the spark heat produced by battery ignition is more nearly uniform than that from a magneto. Its value at different speeds is always more in accord with the requirements of the engine.

For a long time after battery ignition began to attract attention, it was regarded contemptuously because it was less costly than a magneto. Battery ignition requires fewer parts than a magneto and these parts are much more simple in design and construction; therefore a battery ignition system of the highest possible quality in both workmanship and material will be less expensive than the cheapest magneto.

EXPERIMENTAL CONTACT-MAKERS

In the conventional magneto design, the entire electrical system, the generator winding, condenser and contact-maker, are carried as a part of the armature, but in battery ignition we are not hampered by having a large number of moving parts, nor are we limited by having to consider both generator and ignition characteristics in the same mechanical assembly.

GENERAL TYPES OF BATTERY SYSTEMS

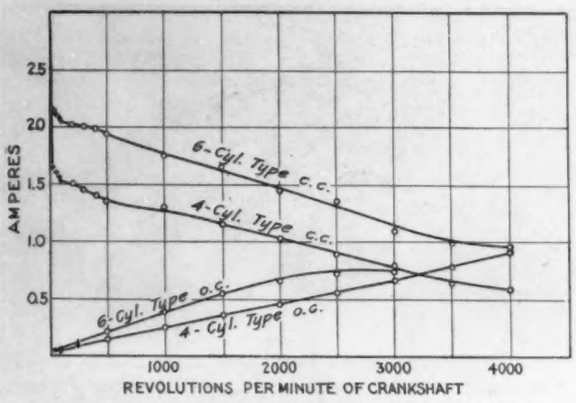
Battery ignition can be divided into two general types —open-circuit and closed-circuit systems. In each system the elements are almost identical, consisting of the combination of a low-tension circuit-interrupting and timing device, a transformer coil with primary and secondary windings and a distributing device for connecting each spark-plug in its proper order to the high-tension winding of the coil. The main difference in the two systems is in the contact-maker or interrupter.

Open-Circuit Contact-Maker.—This is so designed as to close the circuit of the transformer coil momentarily for each spark, the time interval being uniform at all engine speeds. It is operated on the general principle that when a spring is stretched to a given point it will recoil with the same force and at the same speed, no matter how rapidly or how slowly it was stretched originally.

The contact-maker consists of a little steel trigger or lifter, which engages notches (one for each cylinder) cut in the rotating timer-shaft. The lifter being pulled forward by the rotation of the timer-shaft, reaches a point where it slides off, and on its recoil rides over the rounded part of the shaft and strikes a blow against an impact piece or latch, which in turn moves a contact-arm so as to close the primary circuit for an exceedingly brief but uniform time-interval.

The time during which the primary current flows through the coil is about thirty-three ten-thousandths of a second for each spark. By making the resistance of the primary winding low, the current flow for this brief instant is high (about four and one-half amperes), but the time is so short that the actual energy consumed is almost negligible. A six-cylinder ignition-system requires less than six-tenths of an ampere at the highest engine speeds. With a system of this sort, ordinary dry cells are economically used as a source of current supply.

Owing to the fact that each operation of the open-circuit mechanism is complete and the lifter on its return stroke opens as well as closes the circuit, current flows only when the engine is running and even then only for an exceedingly short time interval for each spark. Because of this fact there is no danger of accidental battery discharge should the ignition switch be left closed. The ef-



CURRENT CONSUMPTION FOR OPEN AND CLOSED CIRCUITS

ciency of this type of ignition is certified by the fact that it is, and has been, widely used for the past twelve years.

Closed-Circuit Contact-Maker.—This is operated by direct cam action and the electrical windings are proportioned differently from those used with open-circuit systems. Its form has been evolved from that of the magneto and consists of a simple arm or lever carrying a contact point controlled by a spring to bring the contacts together, and actuated by means of a cam on the timer-shaft.

By reason of this simple cam action, the circuit is closed for a larger time-interval than with the open-circuit system. The duration of the contact varies with the speed,—long contacts at low speeds, becoming shorter and shorter as the speed increases to the critical limit. The device is much simpler than is required by the open-circuit system, but with it more current is consumed, and should the ignition circuit be left closed after the engine has stopped, the battery will be discharged at a rate limited only by the resistance of the primary circuit.

The current characteristics of the two systems are directly opposite. With the closed-circuit system the current is a maximum when the engine is not running, falling as it starts and decreasing as the speed is increased. In the open-circuit system the current consumption is zero at zero speed and increases in direct proportion to the speed. While the open-circuit type of ignition is widely and successfully used at present, the closed-circuit is undoubtedly simpler in construction, and its manufacturing cost is considerably less. It is therefore in wider use than any other type.

DEVELOPMENT OF PRESENT BATTERY SYSTEMS

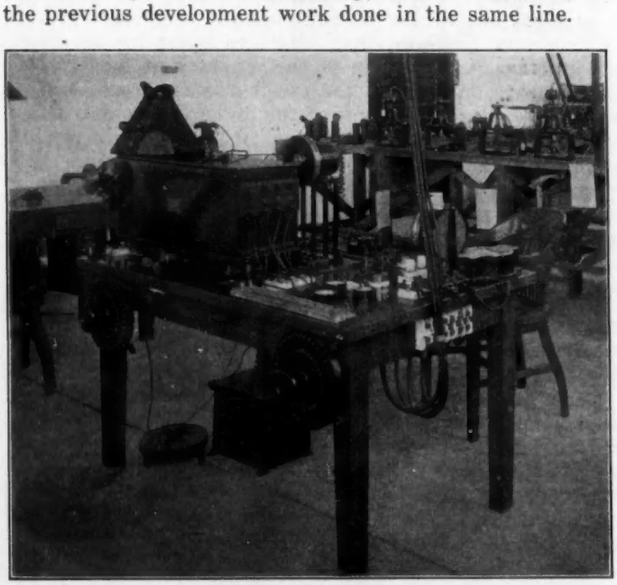
The simple ignition system in common use today is really the result of years of close study and careful step-by-step design. Its production in quantities has been a problem of manufacture. Previous to the development of the automobile engine little was known of actual ignition essentials; ignition equipment used on stationary and other internal combustion engines was primitive and cumbersome—entirely unsuited to the requirements of a high-speed multicylinder engine. In spite of the rapid progress of the last few years, we are only just beginning to discover many of the actual facts and necessary quantities with which we have to work.

Our ignition system must produce a spark hot enough to ignite rich and lean as well as normal mixtures of gasoline and vapor. It is not known just how hot this spark must be, but it must be hot enough. Fundamental rules and formulas have not been available, and the quantities involved have been so small that rules would probably not have been of much use anyway. Practically all of the development to date has been accomplished by slow, painstaking and expensive "cut and try" experimental work, starting only with known principles and elements.

The development of a new ignition system is not a matter of laboring to find some new and startling principle, making an experimental outfit, rushing it through the shop and having it appear on cars all over the country in a few weeks or months. It is a work of refinement, of careful research and of almost endless experiments with many hundreds of models.

The factor of maximum efficiency (electrical, mechanical and functional) and the commercial factor of economical production, are of course of prime importance in designing an ignition system.

The first step taken in working out a recent system was carefully to measure and test existing models and types and to study them fundamentally, also to review all of the previous development work done in the same line.



PART OF IGNITION DEVELOPMENT LABORATORY

Inertia in the Contact-Arm.—One of the first facts brought out by the experimental department was the desirability of reducing this inertia—seemingly an easily solved problem. However, before a final contact-arm was decided upon and produced, hundreds of them differing in minute details were made and tried. Various kinds, shapes and sizes of control springs, many different kinds of pivots, arms fulcrumed as first, second and third-class mechanical levers, in all a large number of experiments were necessary before the desired result was achieved.

Theoretically, a contact-arm of one-quarter the weight will have only one-sixteenth the inertia. It will be much easier to start moving, and much easier to stop after it has started. Consequently, the lighter contact-arm will follow the cam more closely and require less spring tension. This in turn reduces wear and lessens the hammer blow of the contact points and a consequent tendency to bounce when striking. Again, a further advantage in performance was obtained by reducing the distance over which the contact-arm traveled. This was done by reducing the diameter and lift of the cam; the contact-arm was arranged so as to engage the cam on the end instead of the middle, thus reducing the "throw" and shortening the gap at the contact points.

Naturally the contact-arm can move faster with less inertia effect in traveling six-thousandths of an inch rather than twenty. This reduction in the gap involved some electrical problems, but these were successfully solved.

Overcoming Harmonic Vibration.—Then another problem arose, one always involved in the design of high-speed reciprocating mechanisms, no matter how large or how small, and that is the bugbear of harmonic vibration. This is of course a characteristic of all spring-operated oscillating parts, and is a problem involved in the design of contact-arms as well as of crankshafts.

Troublesome vibration is materially decreased by a reduction in the inertia of the contact-arm and consequently of the contact-spring. Tests of several hundred contact-arms and springs finally led to the development of one so arranged as to change slightly its fulcrum or bearing point throughout its range of movement—a sort of cantilever arrangement in miniature. This was found practically to dampen the harmonic vibration of both the contact-arm and contact-spring within the limits of operation of the device.

Advantages of One-Piece Cam.—After experimenting with many forms, it was decided to make the cam in one piece with the shaft instead of having it adjustable, for the following reasons:

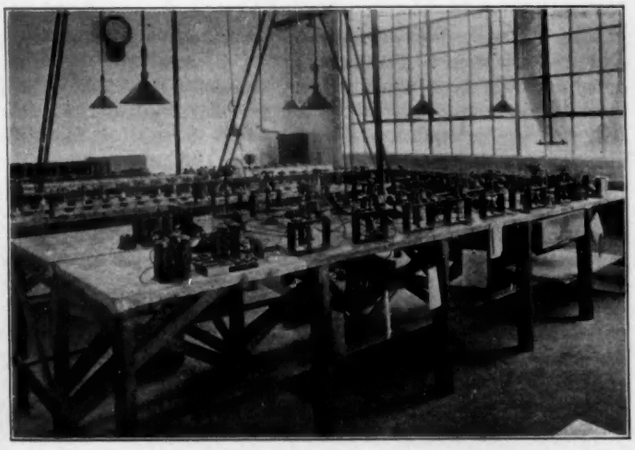
(1) The adjustable cam is convenient and useful only when the initial installation is made. It is of no subsequent use, because the ignition timing if fixed cannot get out of adjustment. An adjustable cam is only one more vulnerable part for the car owner to tinker with. If he must adjust his timing after the car leaves the factory he can tinker with the linkage to his heart's content.

(2) By making the cam and shaft in one piece, its outside diameter can be made small, thus reducing its peripheral velocity and minimizing friction.

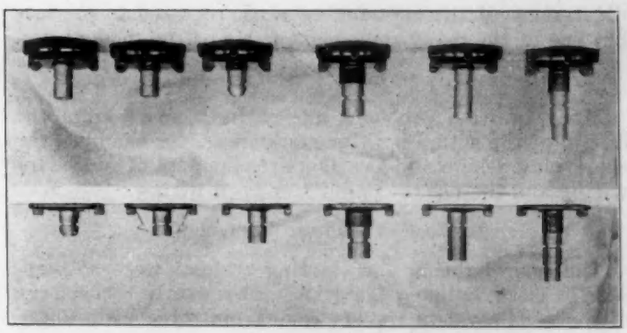
(3) It can be manufactured with far greater accuracy.

(4) The construction is greatly simplified and the cam itself is less costly to manufacture.

After the details of the design were decided, there came the many problems of manufacture, the designing of special grinding equipment and methods of hardening. These problems not only came up for consideration after the design was tested by the experimental department, but also were important factors in working out the design itself.



LIFE TESTING OF IGNITION EQUIPMENT



SHANKS NECESSARY TO ADAPT ONE TYPE OF DEVICE

The condenser in an ignition system acts as a sort of shock absorber for the contact points. Shunted across the contact points, it absorbs the current from the primary circuit at the instant the points are opened and thus renders the break more abrupt. It is usually placed in the coil-container, and extra wiring between the contact-maker and the coil is required. Its distance away from the contact-points hampers its beneficial action and increases its necessary size and capacity. Surprisingly little is known about condenser and condenser design from the standpoint of current absorption, and in order to solve the problem of this particular contact-maker design it was necessary to make a thorough study of condenser fundamentals.

The condenser is the most temperamental part of an ignition system. Its manufacture has always been surrounded by all sorts of factors and its function as a current absorber has been more or less uncertain. In attempting to track down all of these variable factors, it was discovered that the current absorbing qualities of a condenser are not altogether a matter of electrostatic capacity, and that other qualities are just as important as the capacity. Before the condenser detail was finished an entirely new method of manufacture and construction was developed. The resultant condenser was much more simple and effective and was so small that it could be mounted directly on the contact-maker without any intervening wiring.

This was not only an important step forward in the simplifying of the contact-maker; it also reduced the amount of primary wiring and greatly simplified the construction of the coil, permitting it to be mounted symmetrically in a close-fitting container. The efficiency of the new condenser in its new location was such as to increase greatly the life of the contact-points. The points on all of the large number of instruments tested withstood long use so well that no adjustments were required in the equivalent of more than one hundred thousand miles of service. For a time this even led to the contemplation of a non-adjustable contact-maker.

Throughout the entire design every effort was made to avoid non-contributing mechanical details. Every machine screw, every part and every dimension was called up before a committee consisting of the electrical research engineer, the mechanical research engineer, the production expert, the chief tool designer, and sometimes of the sales manager. The result was an ignition system with a greatly increased efficiency, a high quality of workmanship, while the cost as compared with previous systems was substantially lowered.

This particular system is by no means to be considered as being an ultimate design. It is used merely as an

illustration of the painstaking work required to produce but one of the many component parts of the modern car.

Problems Introduced by Outside Factors

Many ignition problems are entirely apart from the design of the actual ignition equipment; for example, the spark-plug design and location, arrangement of secondary wiring and the use of conduits or open wiring.

Effect of Voltage Variation

The early lighting and starting systems were not capable of close voltage regulation. Frequently the voltage of a six-volt system would range from three volts under cold weather cranking conditions to nine or ten volts when the engine was running at high speed. The problem of designing coils and contact-makers to supply an amply hot spark at low voltage while avoiding burning of the points at high voltages, has required a vast amount of experimental work. Manufacturers of lighting and starting equipment have also succeeded in obtaining a much closer regulation on generator equipment than was at first possible, so that to-day under ordinary conditions the voltage on any car rarely falls below four and seldom rises above seven. A successful modern ignition system will furnish an amply hot spark at three volts and the contact points will not burn even if operated for long periods at nine volts.

Automatic Spark-Advance Mechanisms

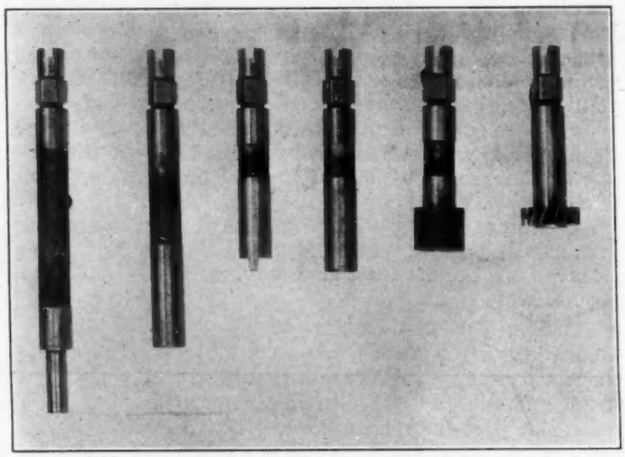
In the early development of the open-circuit system, one of the problems that had to be overcome was that of lag (so-called), a constant time element being required to produce the spark. This time element corresponds to a greater or less number of degrees of movement of the crankshaft at different speeds. The so-called lag was overcome by using a centrifugal-governor arrangement for advancing the spark in a given relation to the speed. With the lag thus compensated, it was found possible to go a step farther, the automatic spark-advance being the result.

The present-day automatic mechanisms are not usually made to act in accordance with the exact spark-advance requirements of the engine, but are so proportioned as to approximate its requirements at different speeds and under varied conditions. If an auxiliary manual control is used the skilled driver can, if he so desires, supplement the operation of the automatic advance by shifting his spark lever to meet the imagined or actual requirements of his particular engine and to conform with his own particular idea of spark timing. This so-called semi-automatic advance will greatly improve engine performance and save gasoline. The engine will run cooler, and the driver can be relieved of the necessity of using his spark lever in driving.

Standardization of Ignition Mountings

The ignition mounting deserves the serious consideration of every designer. The ignition distributor is now frequently mounted on the generator unit, and it is contended that this results in a reduced cost of installation by reason of the smaller gears and simpler mounting required. The author is of the opinion, however, that it is better wherever possible to mount the ignition distributor directly on the engine. The mechanical drive is much more direct and timing of the ignition is much more accurate and less liable to derangement in the event of repair work or adjustment to the generator.

The general details of ignition installation are in great need of standardization, and it is a relief to realize that the Standards Committee of the Society has this general subject under consideration. At present the huge number of special fittings and installations required is an enormous manufacturing burden and an important cost factor. Any standardization that will permit one or two ignition mountings to take the place of the large number now used should be welcomed by manufacturers of ignition systems, engines and complete cars.



Distributer Shafts Required for One Design

It should be possible to standardize the socket or mounting that holds the ignition distributor so as to make all of them interchangeable. We are now furnishing six different distributor shanks to various car manufacturers, and even with six shanks from which to choose, we are still frequently asked to manufacture special shanks.

The ignition drive-shaft and connection is another detail worthy of standardization. We now must make up a wide variety of shafts as well as shanks. The shaft situation is even more serious because we must supply them for four, six and eight-cylinder engines, multiplying the necessary varieties by three.

Author's Conclusion

Ignition equipment installation can be standardized as readily as any other electrical or mechanical equipment, and it is doubtless only a matter of time when it will be done. I believe, however, that the mechanical details of installation now suggested for standardization can be still further refined, and that at some later time smaller dimensions can be used with resultant economies.

The seemingly narrow subject of ignition—only one of the thousand and one things that enter into the construction of the finished automobile—is a subject requiring an enormous amount of thoughtful consideration and highly specialized research work.

Unquestionably it is the same with most of the other parts of the car. There is still much to be accomplished, many problems to be solved. It is a work for many men and many minds in close cooperation.

Notes on Automotive Storage Battery Practice

By WM. H. CONANT* *(Member of the Society)* *Illustrated with* CHART

The effect of requirement upon design is an important feature in engineering progress. This can perhaps be shown to good advantage by the following tabulation, which indicates the relative importance of the factors that determine design for certain important fields in which storage batteries are used:

1. *Submarine*
a. Capacity
b. Weight
c. Life
(Price)

2. *Electric Vehicle*
a. Weight
b. Capacity
c. Life
d. Price

3. *Railroad Car Lighting*
a. Life
b. Capacity
c. Price
d. Weight

4. *Stationary Power Plant*
a. Life
b. Price
c. Capacity
(Weight)

5. *Automotive*
a. Price
b. Capacity
c. Weight
(Life)

The most striking feature of this tabulation is the Orbit of Price, as it might be called. Under the first heading it is shown in parentheses to indicate that it does not appear as a serious factor of design. Under the second heading it appears as the factor of least relative importance. Under the third and fourth headings it takes successively third and second positions, and in the automotive industry reaches first place.

The next feature to note is that while in all other classifications Life occupies the first, second or third position, it plays little if any part in the demand that determines design for the Automotive field. The author does not believe this to be a correct tendency, but is trying to review the actual situation with the hope that future practice may change.

The ideal design of storage batteries for any purpose contemplates a proper balance between the three factors represented by positive plate, negative plate and electrolyte. If the positive electrode has more capacity or life or can discharge at more rapid rate than the negative, or if both the electrodes have capacity or be capable of rates beyond those warranted by the supply or circulation of electrolyte, then naturally the weaker factor determines the total result, whether it be capacity, life, or rate of discharge. What is said of the positive could be said with equal force of the negative electrode, when the latter is better designed as regards capacity, life or rate of discharge.

While these three are the vital factors, yet the separator, or insulating medium, is of nearly equal importance in automotive practice, because price considerations have eliminated the auxiliary rubber separator and thrown a greater burden upon the wood diaphragm. As the form of separation in this class of service plays an important part in life, capacity and voltage, it must be selected and designed with almost equal care, for if the plates be capable of producing long life but for the failure of separators to insulate them properly, then is their value depreciated.

This interdependence of storage battery factors can be indicated by a further tabulation. Every statement about battery characteristics is relative and can be likened to the combinations that can be set up by a railroad signal-tower switching machine in which every lever controlling a switch or signal interlocks with many others, so that each movement depends upon certain others. In the storage battery, for example:

Temperature has its decided effect upon:
Capacity
Voltage
Specific Gravity
Life

Again, the rate of discharge determines:
Capacity
Voltage
Specific Gravity
Temperature

On the other hand capacity is affected by:
Area of plate surface
Porosity of active material in the plate
Porosity of separators
Quantity of electrolyte
Specific gravity of electrolyte
Circulation of electrolyte
Rate of discharge

And these relationships might be shown throughout other spheres of the chemical and physical changes that take place.

One point on which engineers may desire comment is the matter of internal resistance. It is generally thought that the drop in voltage on discharge is a manifestation of the battery's internal resistance and that there is an important variation of this resistance for various compositions of plate. Actually the internal ohmic resistance is a negligible quantity, although its increase is progressive during discharge, owing to progressive sulphation, and is of such academic value and so nearly uniform in all makes of battery of the same capacity that it need not be considered seriously.

The cause of voltage drop and its acceleration with increasing rate of discharge is sometimes called polarization. This refers to certain physical processes within the battery, of which the two most important are:

(a) the dilution of molecules of electrolyte within the pores of the plates, or immediately adjacent to their surfaces, so as to arrest the chemical process of producing lead sulphate from the peroxide of the positive plate and the spongy lead of the negative plate at the expense of the free sulphuric acid surrounding them; and

(b) the formation of this sulphate which gradually reduces the amount of porous surface available for fur-

*Detroit Division Manager, Gould Storage Battery Company.

ther chemical process and thus delays acid diffusion. In other words, there is a lag in the chemical process caused by the time required for strengthening the solution when it comes in contact with the active material; this strengthening is done automatically by the circulation of the electrolyte and is called diffusion. The more rapid the rate of discharge, consequently, the more pronounced is this lag, which explains the peculiarity whereby a storage battery, after being discharged at a high rate until no more current is obtainable, will recuperate and discharge further after being allowed to stand open-circuited for a given length of time. The specific gravity of the electrolyte has in the interval become equalized and the strengthened solution is brought in contact with active material that is deeper within the plate pellets and has not been converted into sulphate.

High rates of discharge for short periods do not absorb so much of the life of the battery as long discharges at low rates, because the coating of lead sulphate over the surface of the active material in the former case is not so dense. This coating, therefore, (a) is more easily converted back into its original state with less chemical disturbance of the surface and loosening of particles to fall in the form of sediment; and (b) produces less heat from the effect of the current passing through the lead sulphate, which is a poor conductor as compared with the lead peroxide and spongy lead. Automotive service, in fact, is not as trying on storage batteries as may be believed, and with some little latitude allowed in the matter of price limitations, much better life results can be produced.

The operating demand on a starting battery today is affected by

(a) Fuel grade
(b) Cranking speed
(c) Engine design and manufacture

Under the first heading nothing need be said because the situation is so generally recognized, but when this is taken in conjunction with the higher cranking speed needed to start the same engine on poorer fuel, it is evident that more is required of the battery than formerly. If, now, under the third heading it be considered that for reasons of both design and manufacturing economy, engines today are much stiffer than formerly as well as with greater weight to be turned by the starting motor, it must be clear that more battery capacity is essential, if only enough has been used hitherto.

These considerations are sufficient in themselves, but we must also consider the maximum battery capacity available under cold weather conditions, as regards effect on fuel, lubrication and on the battery itself.

The action of low temperatures on gasoline and oil has been covered thoroughly in other papers presented before this Society, and even that on batteries is fairly well recognized, but the combination of all three in conjunction with the greater demands now being placed on batteries—as previously described—probably has not appealed to engineers of automobile makers as much as it has to those connected with starting and lighting equipment manufacturers.

Fig. 1 shows clearly the effect of temperature on voltage and effective capacity. Curves *A*, *B* and *C* show the cell voltages of discharge at 70, 32 and 3 deg. fahr. respectively, the rate being 500 amp. Attention is drawn to the increase in open-circuit and charging voltages, which vary inversely with temperature, and to the increase in the temperature on discharge at this abnormal rate. The temperature of a battery drops when it is discharged at a normal or moderate rate. It rises, however, with abnormally high rates of discharge and at an accelerating rate both for lower initial temperatures and for the continuation of individual discharges. In one minute the following effective outputs were obtained for the different temperatures: 70 deg., 11.44 watt-hr.; 32 deg., 9.84 watt-hr.; 3 deg., 7.84 watt-hr.

The difference in shape of curve *C* from that of *A* and *B* is due to the rapid rise in acid temperature as shown by the difference between initial and final readings of 3 and 46 deg.

The voltage and specific gravity during charge vary inversely with the temperature, whereas discharge voltage, ampere-hour capacity and efficiency vary directly with temperature. Internal ohmic resistance, too, actually does increase with very low temperature.

The temporary loss of capacity in storage batteries from low temperature is due to both physical and chemical actions and may be likened to the sluggishness of the human muscles when thoroughly chilled. Furthermore, there is an internal drop in temperature that accompanies discharges at normal rates. Abnormal rates of discharge, however, raise the temperature until it mounts very rapidly toward the end of discharge at a high rate. Charging produces an increase of temperature, depending upon the proportion of charging current absorbed in the electrolytic action, so that after a battery is fairly well charged, a continuation of the same rate produces a greater proportion of heat than during the early part of charge. Low temperatures have no injurious effect upon storage batteries other than to curtail the capacity temporarily. High temperatures, however, shorten battery life both because of the effect on the thin wood separators and because the lead and antimony are attacked by sulphuric acid when hot, but are not when cold.

We observe, then, these conditions:

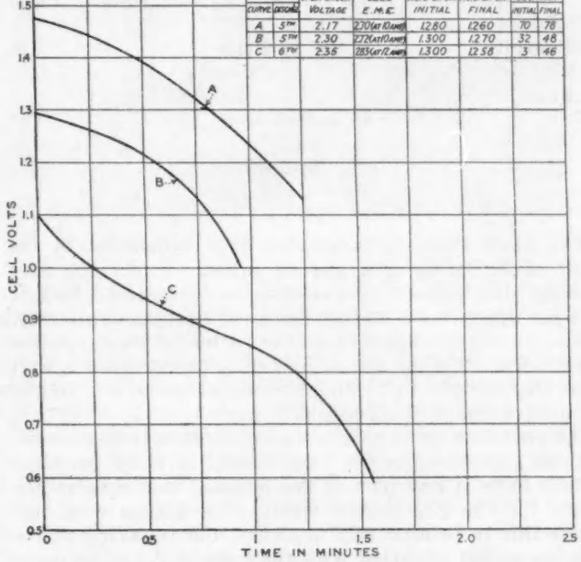


FIG. 1—CURVES SHOWING RELATION OF TEMPERATURE AND CELL VOLTAGE

1. Maximum capacity is now needed from present battery equipments.
2. The attempt to obtain maximum capacity results in overcharging.
3. Overcharging produces heat.
4. High discharge rates needed for starting engines produce heat.
5. High temperature is injurious to batteries.

The inevitable conclusion therefore is that larger batteries are needed to give the results demanded at present and to satisfy car owners with their longer service. In general batteries will give longer life when kept in a slightly undercharged condition than when kept overcharged. This applies certainly to those used in regulating or "floating" service, as on automobiles, if not so strongly to batteries in other service. One of the most puzzling things in automobile engineering, is the determination of life and capacity characteristics of storage batteries. Some tests have recently been made that seem to point the way toward a simple and inexpensive method of determining such characteristics.

Any desired number of battery cells are connected in series and alternately charged and discharged, a clock switch being set to give any proportion of charge and discharge periods; the rate for each period is regulated in the respective circuit. All battery cells should be of the same capacity and should be connected in series throughout the test. A recording ammeter should be placed in the circuit in order to preserve a history of the cycles; thermometers should be placed in one cell of each battery; voltage readings should be taken; first, to determine whether the discharge period has been proportioned so that batteries are not discharged below a proper point and then, at intervals during the test, to know whether there is any lack of uniformity among the different cells. All voltage readings should be taken on individual cells and not on complete batteries so as to avoid observing average instead of unit conditions.

It is important in moderate or warm weather, or if tests are to be conducted at high rates, to provide artificial ventilation by means of forced draft. In a general way, it is satisfactory to use just as high rates of charge and discharge as may be desired provided the battery temperature does not exceed 110 deg. fahr. at any time. A careful record of the number of cycles should be kept and capacity tests should be taken at intervals, as for instance at the end of 15, 30, 45, and 60 cycles.

These capacity tests should be taken with great care, first, to keep the discharge rate in amperes constant; second, to read cell voltages at such intervals that proper curves can be plotted; and third, to stop the test when cells have reached the point at which the drop of the voltage curve is too steep to be useful. The previous treatment of the battery should be recorded in connection with every capacity test; that is, the number of operating cycles to which it was subjected preceding the test and the rate and length of charge before the test began. Initial and final readings of both specific gravity and temperature should be recorded.

TABLE I—RESULTS OF TESTS OF BATTERY AT VARIOUS TEMPERATURES

Discharge, Rate, Amp.	Test No. I					Test No. II					Test No. III				
	Specific Gravity		Temp. Deg. F.		Time, Min.	Specific Gravity		Temp. Deg. F.		Time, Min.	Specific Gravity		Temp. Deg. F.		Time, Min.
	Init.	Final	Init.	Final		Init.	Final	Init.	Final		Init.	Final	Init.	Final	
100	1.280	1.240	70	75	23.50	1.287	1.253	32	46	20.00	.....	.....	.....	.....	.....
200	1.303	1.271	70	75	4.50	1.284	1.265	32	44	4.30	1.305	1.265	20	55	6.8
300	1.290	1.271	70	76	2.50	1.307	1.275	33	41	1.80	1.300	1.275	10	47	3.1
400	1.287	1.268	70	75	1.25	1.293	1.265	32	40	1.25	1.300	1.268	7	44	1.6
500	1.280	1.260	70	78	1.25	1.300	1.270	32	48	0.90	1.300	1.258	3	46	1.6

Much interesting information is contained in Table I, showing specific gravity, temperature and time readings for a series of tests on the same battery at temperatures from 3 to 70 deg. fahr. for rates of discharge from 100 to 500 amp. Another paper, in fact, might be written on these results and the lessons they teach.

PUBLICATION OF MEMBERSHIP LIST

THE 1917 List of Members has just been printed. All members of the Society are entitled to one copy free, and those desiring it should so inform the office of the Society. The new list contains the names of almost 2600 members. This number includes all in the grades of member, associate member, junior member, affiliate member, student enrollment and affiliate member representative. According to the booklet, members of the Society are connected with 1179 companies and 11 institutions of learning.

One new feature of the present list will be the classification according to engineering interest. Each name in the alphabetical list of members is followed by a letter, indicating whether the member is specially interested in the aeronautic, automobile, marine, or tractor fields of engineering. In some cases it was not possible to secure this information from the members, but it is indicated whenever the facts were obtainable. The arrangement of placing the location of each company at the right has been used so that knowing the location it is possible to locate the company or any members who are connected with the company.

Considerable matter of general interest has been added to the front of the new list. The names of officers of the Society and Sections are given as well as members of the Council, past-presidents and the members of the different administrative committees. The increase in the number of standard committees in the list is quite noticeable. General information in regard to the object and administration of the Society; Sections Meetings and the different S. A. E. publications are set forth. The 1917 regulations governing the Standards Committee are printed as well as the standardization work and other technical researches of the Society. The Constitution of the Society is given in full, together with a complete index to articles and by-laws.

The principal part of the 200-page book is naturally taken up with the alphabetical list of members of the Society and companies. The list of members takes up about 90 pages and the list of companies with which the members are connected required 76 pages of the book. As in previous lists, the nature of the work done by each company is indicated. A summary at the end of the list gives the total number of members and companies.

Current Standardization Work

IN EACH issue of THE JOURNAL is given a complete summary of the current work of the Standards Committee divisions. This includes such matters as the definite recommendations, the subjects being considered for standardization, advance notices of the meetings of the divisions and the list of attendance. It should be borne in mind that the recommendations adopted by the Divisions must be submitted for approval to the Standards Committee, to the Council of the Society, to the Society at either its Annual or Semi-Annual Meeting, and finally to a letter ballot of all the voting members, before finally becoming S. A. E. standards. It is the policy of the Society, however, to keep all the members acquainted with the preliminary work. Only in this way can the best results be secured from the standardization. Suggestions and information regarding the work in progress are always invited from the members.

Since the last issue of THE JOURNAL meetings of the Aeronautic and Tractor Divisions of the Standards Committee and of the Military Motorcycle Committee have taken place. The Aeronautic Division met July 31 at Washington and recommended for adoption standards relating to round wire and flexible and non-flexible cables for aircraft. These dimensions are given below in the account of the meeting. The Tractor Division held an informal meeting in connection with the Fremont Tractor Session of the Society. While no definite recommendations were made, in fact, the purpose of the meeting was not to consider specific subjects for action, a large number of the tractor engineers attended, and valuable suggestions for carrying on the work of the Division resulted.

The work of the Motorcycle Committee is somewhat informal, inasmuch as it is not a regular division of the Standards Committee. There is an urgent need, however, for the standardization of the parts used in the construction of military motorcycles. The Society is the logical body to carry on this work, so that a strong committee has been formed composed of the engineers connected with all the prominent motorcycle manufacturers. With the assistance of the Standards Manager of the Society, this committee is at work and has already made a number of important recommendations.

The division meetings scheduled for the immediate future follow: Aeronautic Division, Aug. 27, Munsey Building, Washington; Miscellaneous Division, Aug. 30, 9.30 a. m., at Congress Hotel, Chicago; Tractor Division, Aug. 31, 9.30 a. m., Congress Hotel, Chicago; Motorcycle Standardization Committee, Aug. 29, 9 a. m., Congress Hotel, Chicago.

FREMONT TRACTOR STANDARDS MEETING

The main purpose of the Division Meeting held Aug. 8 and 9 at Fremont was to secure suggestions regarding the tractor subjects being considered for standardization work from as many tractor engineers as possible. In the absence of Chairman Harry L. Horning, E. R. Greer of the Division acted as presiding officer of the meeting.

The members of the Division present at the meeting were Fred Glover, E. R. Greer, Raymond Olney and George T. Strite. The names of visitors follow:

Andrews, Geo. C.
Armbrust, C. R.
Austin, L. A.
Beecroft, David
Buffington, Harry C.
Carpenter, Geo. D.
Christopher, G. A.
Clarkson, Coker F.
Clayden, A. Ludlow
De Maringh, Albert
Dodsley, A. H.
Fortner, C. P.
Frost, A. H.
Goodfellow, A. N.
Goodwin, Frank E.
Hanks, M. W.
Jackson, Philip E.
Jones, I. E.
Keys, W. C.
Kinkead, R. S.
Kratsch, Chas.
Krieg, A.
McCormick, Elmer
McVicker, W. J.
Miller, Stanley
Messinger, W.
Olyen, Erling
Parks, M. G.
Rorabeck, C.
Rose, P. S.
Shaw, I. D.
Schwer, Geo. A.
Scarratt, A. W.
Sweeney, E. J.
Smith, J. Henry
Sexton, Frank B.
Strite, G. T.
Thomas, T. R.
Urschel, B. H.
Van Blerck, Joseph
Walker, H. B.
Weggins, E. R.
White, Geo. A.
Whitney, Charles S.
Wigley, R. B.
Winter, E. A.
Worthington, Wayne H.
Yerkes, Arnold P.
Zolinger, F. T.

Punching of Drive-Wheel Rims.—The first subject considered was the possibilities of standardizing the punching of the rims on tractor driving wheels. Mr. Greer said that if a standard method of punching could be used for the rims, lugs could be made to fit any tractor wheel. Standard rims would facilitate the manufacture and interchangeability of standard lugs. The location of the holes might be standardized so that diagonal lugs, straight lugs, or lugs that hook on the rim could be used, although the rims might be of different widths and diameters.

The discussion of this subject showed that standardization of the size of the hole was favored, but it was thought that anything further should be taken care of by the individual designer. It was suggested that the Division proceed with standardizing the size of hole and should obtain information from tractor manufacturers as to their practice in the spacing of lugs, with the idea that later the lug-position might also be standardized.

Specification Forms.—Several of the tractor periodicals have issued specifications for tractors. It was considered, however, that the forms they have used are not complete enough and that the Division should prepare a standard form. Such a form might be used by all the tractor manufacturers in their catalogs. The farmer who is interested in deciding between two tractors could then compare the standard specifications and find out which one was best suited to his needs. It was also said that in some cases the published specifications of tractors are misleading. The standard specification should be arranged so as to give definite and accurate information. The possible order in which items should be included in the form was discussed, and it was suggested that the Division propose a specification to be submitted to the different manufacturers and others interested for approval.

Carbureter Fittings.—The S. A. E. Standard Carbureter Fittings are not heavy enough for some of the kero-

sene carbureters used on tractors. As a result several carbureter companies make special flanges for tractor service. It was the general opinion that the S. A. E. standard should be adhered to, and that the problem could be solved by using a larger size of flange; for instance, a 1½-in. flange with a 1¼-in. carbureter. This would give a heavier flange with a wider space between the holes. The standard gasket with a larger hole could be used.

Tractor Nomenclature.—Many of the parts used on tractors are not found in automobiles at all, so that a separate nomenclature is required for the tractor parts. A committee of the National Gas Engine Association has been working on the matter, and it was suggested that the Division take the results of the N. G. E. A. work, amend it if necessary, and send it out to the manufacturers for criticism.

Fan Belts and Pulleys.—The Division has proposed that the present standards for fan belts and pulleys (Data Sheet 30, Vol. I, S. A. E. Handbook) should be amplified for tractor service.

Joseph Van Blerck suggested that 2, 2¼ and 2½-in. widths be standardized and also that clearances for the pulleys be established. Others believed wider belts necessary, because several tractors use a 3-in. belt for the fan pulley.

It was also suggested that the fan speed be standardized. This would give the fan manufacturers something to work to and they could design their fans to operate at the most efficient speed. A. W. Scarratt stated that this fan speed might be about 2100 or 2200 ft. per min. Before taking any definite action, the Division will consult the tractor manufacturers and obtain the different belt speeds at which fans are operated.

Impulse Magneto Starting Coupling.—The use of the standard coupling would permit the interchanging of magnetos, which under the present conditions is difficult. The National Gas Engine Association has adopted a standard starting coupling, and it was suggested that this might be made an S. A. E. standard. The magneto and engine manufacturers will be consulted by the Division in order to see whether the overall dimensions on the N. G. E. A. coupling are satisfactory.

Connecting-Rod Dimensions.—Since the tractor industry is young, connecting-rods might be standardized so as to have the lengths vary by inches instead of quarter inches. It was said that after the dimensions were established the new manufacturers of engines would follow them, and if the present manufacturers change their product, they also could adopt the standard dimensions. It seemed to be the opinion of the meeting, however, that such standardization was more a matter of design, and that at present other matters could be taken up to better advantage.

Bolts and Nuts.—It was the general opinion that S. A. E. standard nuts should be adopted for tractor use, and that the number of S. A. E. sizes used might be limited. Another suggestion was that square-head bolts should be standardized for tractor service on account of the fact that the farmer usually has nothing except a monkey-wrench, which fits a square-head better than a hex-head bolt.

Wayne Worthington proposed that certain numbers of the A. S. M. E. machine-screw standards be adopted. At the present time such sizes of the A. S. M. E. machine screws cannot be purchased easily. The standardization of the standards would help the manufacturers to obtain the screws they require.

Most farm implements are assembled with U. S. bolts and nuts. Practically all country blacksmith shops are equipped with U. S. S. taps and dies and therefore can give good service in case of a breakdown. On the other hand, with the U. S. standard, according to Mr. Greer, it is almost impossible to make the nut hold. In time, the tractor maker's use of S. A. E. threads will force the country blacksmith to carry S. A. E. taps and dies. The elimination of the one-sixteenth sizes in the S. A. E. threads would help in this respect, because the assortment of dies and taps needed for stock would be decreased.

If only one-eighth-inch sizes of U. S. and S. A. E. standard threads were used for tractors, there would be a marked improvement. The U. S. S. thread could be used when needed in soft metal, aluminum or cast iron, for which the S. A. E. thread is not recommended.

It was suggested that both finished and unfinished bolts and nuts should be standardized so that the rough nuts could be machined to be the same size as the finished one. On the other hand, it was considered unnecessary to standardize the rough-forge bolts, because in time tractor manufacturers will probably use finished bolts, as is the present practice in trucks and automobiles.

Power-Belt Widths.—A standard belt speed of 2600 ft. per minute was recommended by the Tractor Division and approved at the Washington Meeting of the Society. The Division believes, however, that it might be desirable to standardize a 5, 6 and 7-in. belt, or even a 9-in. belt, which are used on a considerable number of tractors. The point was raised that since the width depended on such factors as the power of the engine, the pulley diameter and the belt speed, only one of which (the last) was standardized, the matter of width should be left to the individual engineer. The suggestion was also made that information should be secured from implement and belt manufacturers as to the best widths. This will be considered by the Division and recommendations submitted later.

Spark-Plug Dimensions.—The spark-plugs now used in tractor work are said to be too large. It is believed that the 18-mm. plug recommended by the Aeronautic Division would be desirable. The National Gas Engine Association has adopted the ⅞-18 spark-plug as standard, and this is the size used on stationary engines. Therefore, the ⅞-18 size should be kept as standard. It is now used for automobiles, and if the automobile practice changes, the tractor plug can also be changed.

It has been found that when kerosene fuel is used a smaller size was needed in order to have the plug keep cool. Ignition troubles will be largely overcome, it was said, if a smaller plug, properly cooled, were used. It was finally agreed that the standardization of spark-plugs for tractor engines should be delayed until the metric plug had been tested out thoroughly for aeronautic use.

Piston Rings.—On account of the excessive wear at the top and bottom of the piston ring used in tractor engines, the S. A. E. Standard rings are considered unsuitable for the service. It was suggested that the transverse thickness of the ring and the depth of the piston-ring groove be increased. Better results might be obtained if the thickness only was increased, using the standard width. On account of the groove the piston ring wears away the supporting bridges of the piston, with the result that the rings become loose.

Discussion of Approved Subjects

The tractor subjects approved for standardization at the Washington Society Meetings were then brought up

for discussion. It was the feeling of the meeting that the drawbar and belt-power ratings were entirely satisfactory.

It was suggested that a hard earth road might have been selected instead of firm sod for making the drawbar test. This was favored because better conditions could be obtained more easily in different parts of the country. In answer to this, however, it was said that tractors are compelled to operate on the soil and that a test made on earth road would be difficult to arrange on account of the trouble in preparing a suitable load.

Height of Tractor Drawbar.—The Division fixed this height at 17 in. for average plowing, and it was approved for standardization at the June meeting of the Society. It was said that this height was a good average for drawing wagons and farm implements in general. The standardization of the height will be of assistance both to the implement and tractor manufacturers.

Plowing Speed.—The main object of adopting a plowing speed of 2 1/3 m.p.h. was to give the plow manufacturers an idea of the speed at which the tractor will be operated, as well as to get the farmers to operate the tractors properly. Farmers are inclined to operate the tractors at too high a speed, and therefore a standard speed adopted by all the manufacturers will impress upon the farmers the need of operating at that speed.

Drawbar Design.—The Division has prepared a traction and implement device to be used by all tractors of capacity up to four plows. If the manufacturer furnishes this design on the tractor, implement manufacturers will provide plows, disks and drills with ends to fit. It was decided to circularize the manufacturers and ask them to submit a design for a drawbar with the capacity of three plows and also to submit suggestions for two other sizes for heavier work. The information thus secured will be used by the Division in formulating a standard design.

The Society at the Washington Meeting approved a number of existing S. A. E. Standards as applicable to the tractor industry. These standards were considered by the meeting for the purpose of drawing out any objections to their use. The subject of spline fittings was of special interest to the tractor men. A suggestion was made that a committee be formed to consult with manufacturers and find what splines or shaftings they could use to advantage. The result of this investigation was to be communicated to the rolling mills, who could then take care of the needs of the tractor industry.

The committee will also take up the grades of steel required so that for next year's business the mills and big steel companies can carry the proper sizes and grades. It was the sense of the meeting that a committee be appointed at once to investigate the matter of splines, cold-rolled shafting and alloy steels with the different manufacturers and report to the Tractor Standards Division.

Oversize Cylinders.—This subject created considerable discussion. It was suggested that there should not be more than two sizes of these pistons, and that after the cylinder has been rebored twice, another one should be purchased. The cylinders should be bored 20 and 40 thousandths instead of the 10, 20, 30 and 40 thousandths now recommended.

A suggestion was made that the flywheel housing be added to the list of standards accepted for tractor use. The present standard would be all right for tractor use if 7/16 instead of 3/8-in. bolts were used.

A number of other matters already standardized were discussed. Those present at the meeting evidently were in favor of adopting S. A. E. Standards just as quickly as possible. It was suggested that in case they were not able to secure S. A. E. standard parts, a communication be addressed to the New York office of the Society, which will take the matter up with the manufacturers and endeavor to have them supply the accepted standards.

MEETING OF AERONAUTIC DIVISION AT WASHINGTON

THE subjects of aircraft round wire, aircraft single and multiple strand cable were definitely recommended for standardization at the meeting of the Aeronautic Division held July 31 at the Munsey Building, Washington.

A report from the sub-division on engine weights was presented and discussed briefly. This report contained the complete data possibly necessary in determining the engine weight per horsepower. It will also include the detailed weight of accessories connected with the engine and the total weight of the accessories per horsepower.

In connection with the work of the sub-division on engine testing a letter was presented from C. B. Veal suggesting that experimental tests of aircraft engines should be based on the standard S. A. E. automobile test modified so as to include runs with varying loads at different speeds as well as trials at different atmospheric pressures. Suggestions were also made as to methods of making acceptance and investigation tests, the importance of the latter being to record the performance of machines in actual flight. It is expected the different specifications for testing engines will be presented at the next meeting of the Division.

A report was received from the sub-division on tachometer drive. This contained a number of recommendations on the subject, among them being that the drive shaft was to rotate at one-half crankshaft speed and should be of helical wire wound construction with core wires. The tachometer terminal is to be finished square to fit the square socket on the drive shaft. It was the sense of the meeting that the report should receive careful study by all the members of the Division and should be presented for final action at the next meeting.

The following extracts from the report of the Advisory Committee for Airplane Material, Specifications and Inspection were recommended for standardization:

Aircraft Round Wire.—This specification covers solid high strength steel wire, round section, used in the construction of aircraft when flexibility is of minor importance. A tension test is to be made on each piece or coil of wire. When an individual coil of wire is to be divided into smaller coils to meet special requirements it is sufficient to make one test on the original coil and to cut and seal the smaller coils in the presence of the inspector. Samples for tension test shall be no less than 15 in. long and free from bends and kinks.

TABLE OF PHYSICAL PROPERTIES FOR AIRCRAFT ROUND WIRE

Brown & Sharpe Gage	Diameter In.	Minimum Torsion for 6 In.	Weight in Lb. per 100 Ft.	Number of Bends Through 90 deg.	Breaking Strength Minimum Lb.
6	0.162	11	7.01	5	4,500
7	0.144	12	7.01	6	3,700
8	0.128	14	4.40	8	3,000
9	0.114	16	3.50	9	2,500
10	0.102	18	2.77	11	2,000
11	0.090	21	2.20	14	1,620
12	0.081	24	1.744	17	1,300
13	0.072	27	1.383	21	1,040
14	0.064	31	1.097	25	830
15	0.057	34	0.870	29	660
16	0.051	39	0.690	34	540
17	0.045	44	0.547	42	425
18	0.040	49	0.434	52	340
19	0.036	55	0.344	70	280
20	0.032	61	0.273	85	225
21	0.028	70	0.216	105	175

In making tensile tests on aircraft wire the distance between jaws of testing machine with sample in place and before test shall be 10 in. Wire for this purpose must break at no less than the amount specified in the attached table which herewith becomes a part of this specification.

A torsion test is to be made on a sample cut from each piece or coil of wire as above. Samples for torsion tests shall be straight and no less than 10 in. long. The sample shall be gripped by two vises 6 in. apart; one vise shall be turned uniformly at a speed not exceeding 60 r.p.m. (on the larger sizes of wire this speed shall be reduced sufficiently to avoid undue heating of the wire). One vise shall have free axial movement in either direction. All wire shall be required to stand the minimum number of complete turns shown in the attached table.

A bend test is to be made on a sample cut from each piece of wire as above. Sample for bend test shall be straight and no less than 10 in. long. One end of the sample shall be clamped between jaws having their upper edges rounded to 3/16-in. radius. The free end of the wire shall be held loosely between two guides and bent 90 deg. over one jaw; this is to be counted as one bend. On raising to a vertical position the count will be two bends. Wire shall then be bent to the other side, and so forth, alternating to fracture. The minimum number of bends required is stated in the following table.

A wrapping test is to be made on at least 10 per cent of the total number of coils offered for inspection at one time. The wire shall be tightly wrapped eight consecutive turns around its own diameter with a pitch of substantially the diameter of the wire and then unwrapped maintaining the free end at approximately 90 deg. with the mandril.

It must stand this test without fracture. Because of the possibility of personal error in making this test, failure on one test is not considered conclusive and, if requested to do so, the inspector shall make at least one, but no more than two additional tests on the same piece of wire. If any of these tests are successful the material shall be passed as satisfactory in this respect.

All wire for this purpose shall be furnished in decimal sizes corresponding to the American Standard Wire Gage (Brown & Sharpe Gage). The wire shall be cylindrical and smooth and show no evidence of scrapes, splints, cold shuts and rough tinning, not conforming with best commercial practice. A permissible variation of 0.002 in. above gage on all sizes will be acceptable but no wire will be accepted having a variation of more than 0.0005 in. below gage.

Aircraft Single and Multiple Strand Cable.—Single strand, multiple strand 6 by 7, 7 by 7, and 7 by 19.

A tensile test shall be made upon each individual reel of cable for shipment containing 10,000 ft. or more. On shipments of reels of cable containing less than 10,000 ft. each test shall be made for each 5000 ft. of a size. The tension testing machine shall be of a type satisfactory to the representative of the U. S. Government and shall be standardized with U. S. Standard Weights when considered necessary. Samples of cable for testing for tensile strength shall be no less than 24 in. long. In making tensile tests the distance between jaws of testing machine with sample in place and before test shall be no less than 10 in. Samples for tensile test may be

AIRCRAFT GALVANIZED SINGLE STRAND CABLE (Non-flexible)

Diameter of Cable, in.	Number of Wires	Breaking Strength of Cable, lb.	Approximate Weight, lb. per 100 ft.
5/16	19	12,500	20.65
1/4	19	8,000	13.50
7/32	19	6,100	10.00
3/16	19	4,600	7.70
5/32	19	3,200	5.50
1/8	19	2,100	3.50
1/64	19	1,600	2.60
3/32	19	1,100	1.75
5/64	19	780	1.21
1/16	19	500	0.78
1/32	7	185	0.30

AIRCRAFT GALVANIZED MULTIPLE CABLE *6x7 COTTON CENTER (Flexible)

Diameter of Cable, in.	Breaking Strength of Cable, lb.	Approximate Weight lb. per 100 ft.
5/16	7,900	15.00
1/4	5,000	9.50
7/32	4,000	7.43
3/16	2,750	5.30
5/32	2,200	4.20
1/8	1,150	2.20
1/64	830	1.50
3/32	780	1.30
5/64	480	0.83
1/16	400	0.73

*Six strands of seven wires each.

AIRCRAFT GALVANIZED MULTIPLE CABLE *7x7 WIRE CENTER (Flexible)

Diameter of Cable, in.	Breaking Strength of Cable, lb.	Approximate Weight, lb. per 100 ft.
5/16	9,200	16.70
1/4	5,800	10.50
7/32	4,600	8.30
3/16	3,200	5.80
5/32	2,600	4.67
1/8	1,350	2.45
1/64	970	1.75
3/32	920	1.45
5/64	550	0.93
1/16	480	0.81

*Seven strands of seven wires each.

AIRCRAFT TINNED MULTIPLE STRAND CABLE *7x19 WIRE CENTER (Extra Flexible)

Diameter of Cable, in.	Breaking Strength of Cable, lb.	Approximate Weight, lb. per 100 ft.
3/8	14,400	26.45
11/32	12,500	22.53
5/16	9,800	17.71
7/32	8,000	14.56
1/4	7,000	12.00
7/32	5,600	9.50
3/16	4,200	6.47
5/32	2,800	4.44
1/8	2,000	2.88

*Seven strands of nineteen wires each.

clamped in the jaws of the testing machine in the usual manner to facilitate speed of testing, but in case of failure or dispute on individual tests and at the request of the manufacturer, check tests shall be made by socket-

REELS FOR AIRCRAFT STRAND AND CABLE*

Diam. of Strand or Cable	1000 FEET Diam. Head	Trav. or Dist. betw'n Heads	Diam. Bbl.	Diameter Arbor Hole	3000 FEET Diam. Head	Trav. or Dist. betw'n Heads	Diam. Bbl.	Diameter Arbor Hole
1/32	12	4	8	1 1/8	12	4	8	1 1/8
1/16	12	4	8	1 1/8	12	4	8	1 1/8
5/64	12	4	8	1 1/8	16	4	10	1 1/8
3/32	12	4	8	1 1/8	16	4	10	1 1/8
7/64	16	4	10	1 1/8	16	7	12	1 1/8
1/8	16	4	10	1 1/8	16	7	12	1 1/8
9/64	16	7	12	1 1/8	16	10	8	1 1/8
5/32	16	7	12	1 1/8	16	10	8	1 1/8
11/64	18	7	12	2 1/8	18	10	8	2 1/8
7/32	18	7	12	2 1/8	18	10	8	2 1/8
1/4	18	10	10	2 1/8	24	10	10	2 1/8
9/32	18	10	10	2 1/8	24	10	10	2 1/8
1 1/32	18	10	8	2 1/8	32	16	16	2 1/8
5/16	18	10	8	2 1/8	32	16	16	2 1/8

Diam. of Strand or Cable	5000 FEET Diam. Head	Trav. or Dist. betw'n Heads	Diam. Bbl.	Diameter Arbor Hole	10000 FEET Diam. Head	Trav. or Dist. betw'n Heads	Diam. Bbl.	Diameter Arbor Hole
1/32	12	4	8	1 1/8	16	4	10	1 1/8
1/16	16	4	10	1 1/8	16	4	12	1 1/8
9/64	16	7	12	1 1/8	16	10	8	1 1/8
5/32	16	7	12	1 1/8	16	10	8	1 1/8
7/64	16	10	8	1 1/8	18	10	8	1 1/8
1/8	16	10	8	1 1/8	24	10	10	1 1/8
9/64	24	10	10	1 1/8	24	16	10	2 1/8
5/32	24	10	10	1 1/8	24	16	10	2 1/8
11/64	24	10	10	2 1/8	24	16	10	2 1/8
7/32	24	10	10	2 1/8	32	20	16	3 1/8
1/4	32	18	16	2 1/8	36	22	18	3 1/8
11/32	32	18	16	2 1/8	36	22	18	3 1/8
1 1/32	32	20	16	3 1/8	50	16	26	3 1/8
5/16	32	20	16	3 1/8	50	16	26	3 1/8

In making racks for the above reels allow 4 inches more width than the traverse specified above. *All dimensions in inches.

ing the samples with pure zinc. Cable for use in the construction of aircraft must break at no less than the amount specified in the attached table.

At least one bending test is to be made on a sample cut from each 50,000 ft. of cable of a given size. Each sample must be bent once around its own diameter and straightened again at least 20 times in succession in the same direction of bending without any of the wires breaking.

A torsion test is to be made on one wire from each sample of cable taken for tensile test. The wire is to be gripped by two vises 4 in. apart; one vise shall be turned uniformly at as high a rate of speed as possible without perceptibly heating the wire. One vise shall have free axial movement in either direction. The number (N) of whole turns through which the wire must stand twisting is given by the formula:

$$N = \frac{1.1}{d}$$

where d equals the diameter of the wire in inches. Failure of one piece of wire to show full number of turns specified in the above torsion test shall not be considered cause for rejection, but in each case two additional tests shall be made on two more wires from the same sample of cable and if both samples meet the requirements of the specifications the strand shall be accepted in this respect.

No variation is permissible below nominal diameter. Cable having a diameter of 1/32 to 5/32 in. inclusive shall have a permissible variation of 10 per cent above size and cable having a diameter of 3/16 to 3/8 in. inclusive shall have a permissible variation of 7 per cent above size.

The members present at the meeting were: Charles W. Manly, chairman; F. W. Caldwell, Roger Chauveau, H. C. Dickinson, F. G. Diffin, Spencer Heath, Thomas H. Huff, Grover C. Loening, K. W. Zimmerschied; General Manager Coker F. Clarkson, and Standards Manager M. W. Hanks.

PROTECTIVE COATINGS FOR METALS

The Aeronautic Division of the Standards Committee is now engaged in a study of the various kinds of anti-rust treatment of metals. This subject is exceedingly important at present, on account of the need for protecting many of the bolts, nuts and fittings used on aircraft from the action of the elements. It is planned to secure as many samples as possible of treatments making use of chemical or heat methods or a combination of the two, for protecting metals. Members of the Society engaged in the manufacture of such processes are requested to send complete information to the Standards Manager of the Society at the New York office. What is desired is a sample of the metal actually treated by the process, together with complete description of the process and any claims made as to its effectiveness.

MILITARY MOTORCYCLE STANDARDIZATION

The meeting of the Motorcycle Standardization Committee, the work of which is being conducted under the auspices of the Standards Committee of the Society, was held Aug. 6 at Atlantic City, during the convention of the Motorcycle and Allied Trades Association. Lieut. F. G. Hecox, U. S. A., who has spent a year on the Mexican border, where he was in close touch with the operation of motorcycles, told the committee of the difficulty in getting the full value from the motorcycle. He emphasized the necessity of organizing a motorcycle corps with centralized control, and training corps located so that the men can be schooled for the service. A centralized control will keep the service in trim for quick action, decrease the number of accidents and breakdowns due to inexperience, and permit the necessary repairs to be made in the shortest possible time. Lieut. Hecox was of the opinion that a trained motorcycle rider is far more likely to make a good soldier than a soldier to make a good motorcycle rider. The regular army will require 9000 motorcycle riders, and the national army three times that number, so that it is necessary to have a training camp capable of turning out a large number of experienced riders at once.

To exert every effort toward bringing such an organization about, it was the unanimous sense of those present that a committee composed of K. W. Zimmerschied, T. W. Henderson, W. S. Harley, F. W. Schwinn and Frank Weschler, pray for an audience with Secretary of War Baker to present the following resolution:

Whereas, At a meeting of the Motorcycle Manufacturers, upon request of the Motor Transportation Branch of the United States Army, for the purpose of standardizing motorcycles and parts thereof, it has been brought to the attention of the manufacturers that the existing necessity of organization and centralized control of military motorcycles is very great; and whereas this necessity of organization is deemed fully as important as the standardization of the machines, be it therefore

Resolved, That motorcycles in military use *must* be under centralized control and operation if the maximum efficiency is to be obtained:

That to obtain centralized control, unit organization is a primary and important factor.

That motorcycle companies should be established with specially trained commissioned personnel and enlisted men.

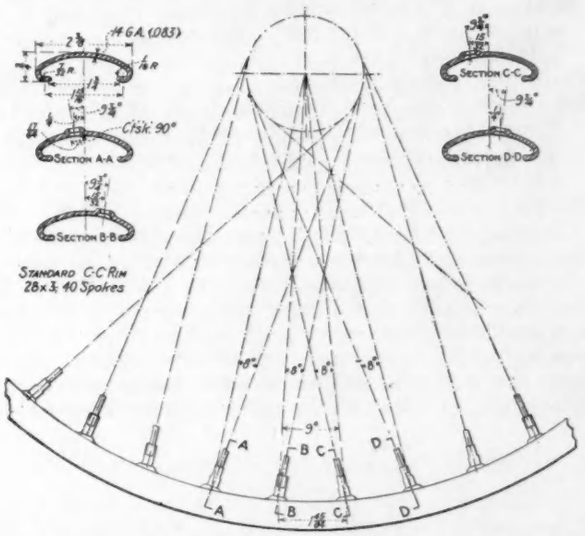
That this organization should come into existence through the powers vested in the President of the United States by the act of June 3, 1917, known as the National Defense Act.

That schools should be established for the training and instruction of officers to command the companies, and for enlisted men in the duties of soldiers and motorcycle drivers.

Military Side Car.—A more comprehensive design of military motorcycle is required, in which proper attention is given to the method of transporting machine guns. A machine gun should be carried in a side-car that will allow the gun to be quickly detached, set up in the usual manner, and the motorcycle taken to the rear.

The Lewis machine gun, the one most commonly used, can be carried in a case 52 in. long, 19 in. wide and 13 in. high. It weighs 83 lb. complete with gun, extra barrel, tripod and loaded magazine pans. The ammunition weighs 64 lb. per thousand rounds.

The Ordnance Department is looking for side-cars designed to carry these guns. It was therefore decided to have each member of the S. A. E. committee give the matter careful consideration, so that a standard side-car can be outlined at the next meeting. The main points to be considered in formulating such a design are suitable strength of platform, method of securely attaching the



gun case, and the quickest possible accessibility so that the gun can be taken out and set up on an instant's notice.

Carrying Capacity.—A communication was read from K. W. Zimmerschied, vice-chairman of the Automotive Transport Committee of the Council of National Defense, stating that the Ordnance Department would be governed by the Committee's recommendation, to the effect that 500 lb. should be the maximum weight to be carried on motorcycles.

Motorcycle Rims.—The 28 by 3-in. rim with cc section, shown in the accompanying drawing, was accepted for standardization on military motorcycles. Complete details regarding this rim are given on page 90 of the July issue of THE JOURNAL.

Head-Lamp Mounting Lug.—There was considerable objection to the head-lamp prong approved at the last meeting of the committee, and it was decided to make the minimum clearance from the center of the hole to the lamp casing $\frac{3}{8}$ in., instead of the 11/32 in. previously recommended, in order to allow safe clearance for the lock washer and nut.

Head-Lamp Supporting Bracket.—The height of the prong for the head-lamp bracket was made 1 19/32 in. A diameter of $\frac{5}{8}$ in. was placed on the supporting flange. This was done in order to permit the use of the $\frac{3}{8}$-in. S. A. E. standard light lock washer of $\frac{1}{8}$ by 3/32-in. section. The head-lamp parts shown in the accompanying drawing have been submitted to motorcycle manufacturers for approval.

Magneto Base Dimensions.—The following magneto base dimensions were approved for military motorcycles. In these the regular S. A. E. taper of 1 to 5 is specified, but many of the other dimensions are smaller than those

of the present standard. The height, length and width of magneto space have not been determined.

	Mm.	In.
Shaft height	45.0	1.771
Distance from center of front base-plate holes to large end of shaft taper	39.4	1.553
Distance from center of front base-plate holes to center of rear base-plate holes	50.0	1.968
Distance between centers of base-plate holes, left to right	50.0	1.968
Large diameter of taper	13.0	0.5118
Small diameter of taper	11.2	0.4409
Length of taper	9.0	0.3543
Taper 1:5 (included angle) 11 deg. 30 min. approx. Woodruff key special 5/16 in. long, 5/64 in. thick		
Plain hole timing lever	5.55	0.2185
Base-plate holes 3/8-in.-16 pitch, U. S. S. Thread for end of magneto shaft 5/16 in.-18 pitch U. S. S., length of thread 0.4173 in		
Advance lever radius	50.0	1.968

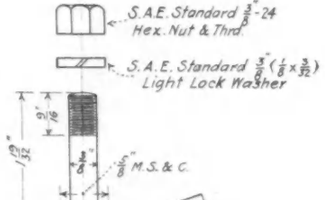
Oil and Fuel-Pipe Fittings.—Soldered pipe connections have given considerable difficulty in Mexico, neither the present flare nor soldered pipes being satisfactory. The flare type is difficult to repair unless special flaring tools are available. Flaring with a nail or other piece of iron splits the copper tube. With the soldered connections the pipe pulls out and a leak results, although all this might be overcome by using a much longer sleeve for soldering. It was therefore decided to secure as many couplings as possible for 5/16-in. outside diameter tubing. William S. Harley of the committee is to give these a vibration test, the results to be considered at the next meeting.

Light-weight Motorcycle.—The possibility of using a lighter type of motorcycle for dispatch work was discussed. Captain Hecox doubted that a machine serviceable for such work could be made of much less than 200-lb. weight. It is desirable to use as few types as possible in order to facilitate the repairs in the field.

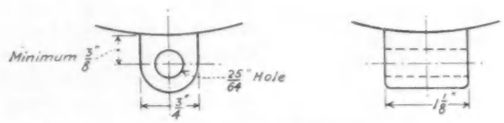
It was said that the German N. S. U. is a light-weight machine that is doing excellent work. A serviceable machine for dispatch work could be made to weigh not over 180 lb., the cylinders being 2.3 by 2.6 in. The parts could be standardized to conform to the recommendations of the committee, with the exception of wheels, spokes and one or two other details. G. V. Rattweiler of the committee was asked to take up the question with other makers of light-weight machines and present a specification at the next meeting providing for as many of the standard motorcycle parts as possible.

The next meeting of the Committee will be held at 9 a. m., Wednesday, Aug. 29, at the Congress Hotel, Chicago.

The following members of the Committee were present at the Atlantic City meeting: F. C. Butler, Jr., William F. Harley, G. O. Hedstrom, T. W. Henderson, L. Ogden, G. V. Rattweiler, Frank W. Schwinn and Standards Manager M. W. Hanks.



HEAD-LAMP SUPPORTING PRONG



HEAD-LAMP MOUNTING LUG

WAR AND THE ENGINEER

By E. W. Rice, Jr.

NO body of men can get together at the present time without soon discussing the subject of the war, which is uppermost in every one's mind.

The war is the one dominating factor in the world life, and thrusts itself before our thoughts whether we wish it or not. We are in the war at last, and will remain in it to the end. Whether it shall be a bitter end or a bright end will depend largely upon ourselves, as it is now our war.

War calls for supreme sacrifices and the deepest devotion, but it also demands something more difficult to give, and that is *work*. War may be said to be the personification of work, not only individual work, but especially organized and disciplined work—disagreeable, dirty, heartbreaking, backbreaking, nerve-racking work, but always work. No nation of loafers ever won a war. Other things being at all equal, that nation or people who are willing to work the hardest will surely win the victory. Now I wish to point out that the enemy we are fighting is recognized as the most industrious organization in the world. Our enemy has prepared for war for fifty years and has been working with ever-increasing energy ever since the war started three years ago. We made no adequate preparation during all this time, and therefore started with a fearful handicap of lost time and lost opportunities. We must not delude ourselves that our enemy is exhausted, but remember that he has the advantage of a flying start. We must accelerate at an incredible rate if we are to get our war motor going fast enough, soon enough to catch up.

War as a Business

War is a business, and must be handled as a highly organized, centralized, autocratic enterprise. We must, no matter how repugnant it may be to our habits and thoughts, temporarily adopt such methods of our enemy as are known to be efficient and successful, because the penalty of failure is death. War is so repugnant to our ideals that it takes time to realize the necessity for and make the colossal changes demanded in every direction. We must, therefore, as I have stated, avoid captious criticism and confine ourselves to constructive criticism, and that sparingly and sympathetically administered.

There is one idea which we must abandon. The great majority of our people, who have no acquaintance with science or engineering, is prone to imagine that this war will be settled quickly by some wonderful new invention, as if by an act of legerdemain; but you engineers realize that such a thing is practically impossible. It is so hopeless that it is cruel to permit any such idea to take hold of the American public. Neither is it possible for the war to be settled by the act of some hero or superman. It can only be settled by the united efforts of thousands of men, each contributing his bit. Team play in our civil army at home is as essential as in our fighting army abroad.

Now, properly understood, the fact that no single great invention is likely to be made which will win the war is no cause for discouragement. It does not mean that there will be no improvement, no new inventions, no new methods devised and put into effect. It simply means that we must not wait for the miracle which will never appear, but get to work and energetically take advantage of all present knowledge. We must survey the field, get at all the facts, carefully determine our plans, and then proceed to put them into practical execution.

We must see to it that ships are built, in respect to size, material and speeds, such that the greatest tonnage may be moved across the seas in the shortest time. In the time element must, of course, be considered the time required to build such tonnage. If an investigation should indicate that cargo ships can be built which will successfully withstand one or more torpedo attacks, and which can also be provided with speed and armament sufficient to give them a good chance of fighting off and getting away from a submarine, they should be built, no matter whether such ships cost more or are less adapted for use after the war, or take a little longer time to construct than those of the ordinary type. It is entirely within the range of possibility that such ships may prove to be the only ones which will be able to navigate the seas with any decent chance of surviving.

Importance of the Airplane

It is a great satisfaction to notice that this country has at last awakened to the importance of developing that great American invention, the airplane, and of manufacturing it on a great scale. We should do everything to help accelerate this work. If we can get airplanes of the right kind to Europe soon enough and in sufficient quantities, experts tell us that it will do more to win the war than a large army.

We must also not neglect the development of the submarine, because if we fail to find a way to drive the submarine from the seas in short order, and fail to make relatively unsinkable and uncatchable ships, we may have to rely on big freight submarines, properly convoyed by fighting submarines, if necessary, in order to get food, material and soldiers to Europe.

We must not forget that, after all, all these things must be done by men collectively, and that therefore it is essential for us to think and act collectively and with reasonable unanimity. We must cooperate, and not nullify our power by quarrels among ourselves. This means that we must be willing to give consideration to the views of others, be ready to make reasonable compromises, and be constantly actuated by a spirit of conciliation. We must make every effort to get men of great experience, industry, and sound common sense in positions of trust and influence. We can then hope to have the helpful suggestions offered by other men of experience and wisdom given intelligent and proper consideration. We must give our chosen leaders reasonable time to make and carry into execution their large plans. We must get behind our leaders and loyally support them, and if, after a long and fair trial, we find that we have made a mistake in our selection, we should then promptly replace such leaders by those more competent, who will surely be found. This is the only way in which a democracy can work and form an effective and efficient organization.

From address given by President-elect Rice at the New York Meeting of the American Institute of Electrical Engineers.

HONOR ROLL OF SOCIETY MEMBERS

THE following members of the Society have been assigned to active duty in some branch of the military or naval service of the United States or of its Allies. In order that this list may be kept complete and up-to-date, members who become connected in any way with the Services are requested to notify the Society office immediately.

Alden, Herbert W., major, Ordnance Officers Reserve Corps, U. S. A., Washington, D. C.

Anderson, William C., second lieutenant, Engineer Officers Reserve Corps, Brooklyn, N. Y.

Clark, Edward L., first lieutenant, Signal Officers Reserve Corps, U. S. A., 2025 Locust St., Philadelphia, Pa.

De Voe, Benjamin H., first lieutenant, Engineer Officers Reserve Corps, U. S. A., R. R. No. 1, Kendallville, Ind.

Fishleigh, W. T., major, Medical Officers Reserve Corps, U. S. A., Washington, D. C. Major Fishleigh has been commissioned as automobile engineer to the Medical Corps, and will be in charge of engineering, maintenance and repairs for motor driven ambulances.

Foss, C. M., captain, Ordnance Officers Reserve Corps, U. S. A., 440 Mill Hill Ave., Bridgeport, Conn.

Gillis, Harry A., major, Ordnance Officers Reserve Corps, U. S. A., Washington, D. C.

Larsen, Lester Reginald, second lieutenant, Engineer Officers Reserve Corps, U. S. A., 385 Twenty-third St., Milwaukee, Wis.

Lay, Arthur J., captain, Signal Officers Reserve Corps, assigned to Aviation Section.

Marmon, Howard, major, Signal Officers Reserve Corps, U. S. A., Washington, D. C.

Martin, Kingsley G., captain, Quartermaster Officers Reserve Corps, U. S. A., assigned to duty as assistant to the Department Quartermaster, Southern Department.

Morgan, M. B., lieutenant, Ordnance Officers Reserve Corps, U. S. A., Washington, D. C. Lieut. Morgan is acting as assistant to Major Wall of the Ordnance Department.

Parker, Richard L., captain, Quartermaster Officers Reserve Corps, U. S. A., assigned to duty as assistant to the Department Quartermaster, Southern Department.

Purcell, Bernard, captain, Quartermaster Officers Reserve Corps, U. S. A., St. Louis, Mo.

Ranney, A. E., major, Ordnance Officers Reserve Corps, U. S. A., Washington, D. C.

Schoepf, T. F., captain, Engineer Officers Reserve Corps, U. S. A., Washington, D. C.

Selfridge, S. W., second lieutenant, Artillery Officers Reserve Corps, U. S. A., Presidio, San Francisco, Cal.

Slade, Arthur J., captain, Signal Officers Reserve Corps, U. S. A.

Thomson, Clarke, lieutenant, Signal Officers Reserve Corps, U. S. A., 526 Land Title Bldg., Philadelphia.

Tolman, Edgar Bronson, Jr., first lieutenant, Engineer Officers Reserve Corps, 5554 Woodlawn Ave., Chicago.

Wadsworth, T. R., captain, Signal Officers Reserve Corps, assigned to Engineering Division of Aviation Section.

Walton, Frank, acting sergeant, Fourth Company, Division Supply Train, Ninety-fourth St. and Park Ave., New York.

Watts, William Arthur, captain, 21st Regiment, Canadian Army, Windsor, Ont., Canada.

PERSONAL NOTES

John R. Cautley, formerly with the Peter A. Frasse Company, is now a Washington representative of the Wright-Martin Aircraft Corporation.

B. D. Gray, formerly president of the Hess-Bright Mfg. Company, is now with the Aircraft Engineering Division, Aviation Section, Signal Corps. He will have particular charge of the inspection of raw materials and of such unfinished materials as wood, fabric and varnish.

J. W. Hobbs has been appointed automobile expert in the Ordnance Department, U. S. A., and is now at the Rock Island Arsenal, Rock Island, Ill.

M. C. Horine has been appointed inspector in the Aircraft Engineering Division, Signal Corps, U. S. A. He is on duty at Washington, engaged in design of special motor-vehicle equipments.

Ladislas d'Orcy, formerly airplane designer with the Lewis & Vought Corp., Long Island City, is now aeronautic expert with the Gardner Moffat Company, Inc., New York.

Capt. Daniel D. Pullen, formerly on duty at West Point, has been assigned to the 7th Regt. of Engineers and will report Aug. 28 at Fort Leavenworth, Kan.

Arthur A. Schupp has been appointed inspector of airplane and airplane engines, Signal Service at Large, War Department, Washington, D. C.

William B. Stout, formerly chief engineer, aircraft division, Packard Motor Car Company, is now with Howard E. Coffin in the office of the Aircraft Production Board at Washington.

OTTO P. STEHN

Otto P. Stehn, general sales manager of the Hydraulic Pressed Steel Company, Cleveland, died Aug. 5 at Baltimore. Mr. Stehn was born June 5, 1876, at Sheboygan, Wis., and entered commercial life at an early age. He became a salesman for the Northern Machine Company of Chicago. Later he was with several other machine tool firms, being at one time manager of the Cleveland office of Manning, Maxwell & Moore. Six years ago Mr. Stehn inaugurated the sales department of the Hydraulic Pressed Steel Company of Cleveland. He was elected an associate member of the Society Feb. 6, 1916. A wife and daughter survive him.

Applications *for* Membership

A list of current applications for membership is given below. The members are urged to send any pertinent information with regard to those whose names are given which the Council should have for consideration prior to their election. It is requested that such communications from members should be sent promptly.

ADAMS, H. J., district sales manager, Garford Motor Truck Co., *Lima, Ohio.*

ALVIN, FORREST J., general manager, United States Motor Truck Co., *Cincinnati, Ohio.*

AMRINE, LEDORE H., vice-president, Scudder Motor Truck Co., *St. Louis, Mo.*

ARMBRUST, C. R., chief engineer, H. J. Walker Co., *Cleveland, Ohio.*

ARMSTRONG, FREDERICK S., electrical engineer, Vesta Accumulator Co., *Chicago, Ill.*

ARNAULT, RICHARD HART, chief mechanical engineer, Acme Wire Co., *New Haven, Conn.*

BALSOM, JOHN J., production manager, Harley-Davidson Motor Co., *Milwaukee, Wis.*

BANNISTER, HARRY BRUCE, secretary-treasurer, Muncie Wheel Co., *Muncie, Ind.*

BECHTEL, JOHN ADAMS, president, Standard Motor Co., Inc., *Norfolk, Va.*

BEIGAL, LINUS, designer, Fergus Motors of America, Inc., *Newark, N. J.*

BELLING, GREGOR C. C., proprietor, Boulevard Motor Works, *Martinsville, N. Y.*

BEIMLING, WILLIAM A., mechanical engineer, Milwaukee Locomotive Mfg. Co., *Milwaukee, Wis.*

BERRY, HERBERT C., designer, chief draftsman, Line Drive Tractor Co., *Minneapolis, Minn.*

BLACK, DAVID FRANKLIN, cost manager, The Bessemer Gas Engine Co., *Grove City, Pa.*

BLAKE, H. C., manager, The Foos Gas Engine Co., *Springfield, Ohio.*

BOHAN, LLOYD J., manager, office, Gurney Ball Bearing Co., *Chicago.*

BURTON, W. DEAN., mechanical engineer, McKeen Motor Car Co., *Omaha, Nebr.*

CASSIDY, EDWARD A., president, Edward A. Cassidy Co., Inc., Madison Ave. & 40th St., *New York.*

CHURCHWARD, JACK, assembler, Ford Motor Co., *Boston, Mass.*

COFFMAN, DON M., vice-president, Wetzel-Hall Co., *New York.*

COMSTOCK, HERBERT FRANKLIN, Aviation Section, Signal Corps, U. S. A., *Chelsea, Vt.*

COX, HENRY G., magneto engineer, superintendent magneto works, International Harvester Corp., *Chicago.*

DEISHER, WALTER N., service manager, The International Motor Co., *Ottawa, Ont., Can.*

DE LORME, ALFRED CHINA, engineer, Splitdorf Electrical Co., *Newark, N. J.*

DEMOTT, RICHARD HOPPER, sales engineer, S.K.F. Ball Bearing Co., *New York.*

DRAY, WALTER R., vice-president, general manager, Hart Parr Co., *Charles City, Iowa.*

DURNELL, FRANK A., production manager, The Keyless Lock Co., *Indianapolis, Ind.*

EISLE, WILLIAM S., draftsman, Pan American Motors Corp., *Decatur, Ill.*

EKSTROM, ERIC SIGFRID, secretary, Mechanics Machine Co., *Rockford, Ill.*

ENSIGN, ORVILLE HIRAM, president, engineer, Ensign Carburetor Co., *Los Angeles, Cal.*

EVANS, R. T., chief engineer, Evans Mfg. Co., *Hudson, Ohio.*

FIRESTONE, ROBERT JAMES, vice-president, Firestone Tire & Rubber Co., *Akron, Ohio.*

FITZGERALD, GERALD, Officers Reserve Training Camp, *Fort Benjamin Harrison, Ind.*

FORSBLOOM, VICTOR I., chief of technical department, Aksai Company, *Rostov-On-Don, Russia.*

FRANKLIN, G. KING, partner, Franklin Way Converter Co., secretary, Great American Truck & Tractor Co., *Chicago.*

GARNER, ORLO F., engineering department, Marvel Carburetor Co., *Flint, Mich.*

GRAHAM, THORNTON GILLMOR, production manager, Falls Rubber Co., *Cuyahoga Falls, Ohio.*

GREENWOOD, H. V., western sales representative, Baldwin Chain & Mfg. Co., *Worcester, Mass.*

GUNLOGSON, G. B., research engineer, J. I. Case, T. M., Company, *Racine, Wis.*

HAMMOND, E. CLYDE, vice-president, general manager, Oliver Tractor Co., *Knoxville, Tenn.*

HARRIS, SAMUEL JASON, general superintendent, Chevrolet Motor Co., *North Tarrytown, N. Y.*

HARPER, H. F., president, general manager, Prudden Wheel Co., *Lansing, Mich.*

HART, JAMES ALEXANDER, sales manager, The Root & VanDervoort Engr. Co., *East Moline, Ill.*

HENNICKE, CARL R., assistant engineer, Lippard Stewart Motor Car Co., *Buffalo, N. Y.*

HERTZ, ARTHUR H., Pacific Coast district manager, Commerce Motor Car Co., *Detroit*

HILL, WALTER H., aeronautical mechanical engineer, Aircraft Engineer Division, Signal Corps, U. S. A.

ICKES, ELWOOD T., special representative, Columbia Steel & Shafting Co., *Pittsburgh, Pa.*

JEDRZYKOWSKI, EDMUND, draftsman, Woods Mobilette Mfg. Co., *Harvey, Ill.*

JANDASEK, JOSEPH, tractor designer, Gray-Plano Co., *Plano, Ill.*

JENKINS, ELBERT J., president, general manager, The Four Drive Tractor Co., *Big Rapids, Mich.*

KEILHOLTZ, LESTER S., chief engineer, Domestic Engineering Co., *Dayton, Ohio.*

KIRKHAM, CHARLES B., chief engineer, Curtiss Aeroplane & Motor Corp., *Buffalo.*

KNAUER, C. H., mechanical engineer, superintendent of engine manufacture, The H. C. Doman Co., *Oshkosh, Wis.*

KOFFER, ALBERT E., sales engineer, The Dayton Engineering Laboratories Co., *Dayton, Ohio.*

KRUER, ARTHUR W., purchasing engineer, Bosch Magneto Co., *Springfield, Mass.*

LEONI, ALFONSO M., chief engineer, The P. T. Wheel Co. of America, Inc., *Dayton, Ohio.*

LIEBERMAN, NATHAN L., specification and material engineer, Curtiss Aeroplane & Motor Corp., *Buffalo.*

LINCOLN, CLOVIS WARD, in charge airplane standardization work, Curtiss Aeroplane Co., *Buffalo.*

LOCKWOOD, FRED. R., superintendent, A. T. Detlaff Co., *Detroit.*

MCALPINE, ROY ALLAN, chief draftsman, Duesenberg Motors Corp., *Edgewater, N. J.*

MCINTYRE, HARRY C., captain, Ordnance Department, U. S. Army, *Auburn, Ind.*

MCINTYRE, JOHN W., draftsman, Auburn Auto Company, *Auburn, Ind.*

MCMASTER, MARCENUS D., inspector airplanes and airplane engines, Aircraft Engineering Division, Signal Corps, U. S. A., *Washington, D. C.*

MARTIN, GEO. E., truck engineer, Velie Motor Corp., *Moline, Ill.*

MAYER, JAMES LEO, designer of pipe-mill machinery, Mark Mfg. Co., *Indiana Harbor, Ind.*

MILLER, CLIFFORD S., battery service engineer, Prest-O-Lite Co., Inc., *Toronto, Ont., Can.*

MILLS, EMORY S., vice-president, Muncie Wheel Co., *Muncie, Ind.*

MINER, PIERRE A., president, National Alloy Steel Co., *Erie, Pa.*

MOONEY, WILLIAM HENRY, sales engineer, The Dayton Engineering Laboratories Co., *Dayton, Ohio.*

OGLESBY, RICHARD ARNOLD, chief engineer, works manager, Quick Action Ignition Co., *South Bend, Ind.*

OSWALD, JOHN W., chief engineer, purchasing agent, Hamilton Motors Co., *Grand Haven, Mich.*

PALMER, HERMANN, chief engineer, Kissel Motor Car Co., *Hartford, Wis.*

PETERSON, FRANK LEROY, service manager, Holt Mfg. Co., *Stockton, Cal.*

QUINCY, EDMUND, vice-president, Miller Transmission Co., *New York.*

RAILSBACK, LEIGH M., assistant to president, Pittsburgh Model Engine Co., *Pittsburgh, Pa.*

SAUNDERS, JOHN LEONARD, guarantee engineer, Electric Boat Co., New London Ship & Engine Co., *Groton, Conn.*

SCHACHT, GUSTAV A., general manager, engineer, The G. A. Schacht Motor Truck Co., *Cincinnati, Ohio.*

SCHELL, ROBERT C., superintendent, Crow Elkhart Motor Co., *Elkhart, Ind.*

SCHWAB, CHARLES M., production engineer, airplane motor division, General Vehicle Co., *Long Island City, N. Y.*

SHUMARD, E. C., chief engineer, The United States Motor Truck Co., *Cincinnati, Ohio.*

SKINNER, ORAMEL H., general superintendent, engineer, The Prest-O-Lite Co., Inc., *Indianapolis.*

SLIGH, CHARLES R., president, Sligh Furniture Co., *Grand Rapids, Mich.*

SPARROW, STANWOOD WILLSTON, assistant chief draftsman, The Metz Co., *Waltham, Mass.*

STALEY, JOSEPH H., secretary-treasurer, general manager, Continental Auto Parts Co., *Knightstown, Ind.*

SWEENEY, E. J., president, Sweeney Automobile & Tractor School, *Kansas City, Mo.*

THEUMANN, HERMAN, chief engineer, Cockrell Mfg. Co., Ltd., *Louisville, Ky.*

TENNEY, PERRY L., manufacturing engineer, T. W. Warner Co., *Muncie, Ind.*

THOMPSON, J. A., chief engineer, Smith Motor Truck Corp., *Chicago.*

UPTON, FREDERICK PAUL, service engineer, Splitdorf Electrical Co., *Newark, N. J.*

VAN HALTEREN, ANDREW S., chief engineer, Prudden Wheel Co., *Lansing, Mich.*

VEEDER, CURTIS H., president, The Veeder Manufacturing Company, *Hartford, Conn.*

VOUGHT, CHANCE M., president, consulting engineer, Lewis & Vought Corp., *New York.*

WADE, GUSTAV, inspector of airplanes and airplane engines, S. S. L., Aircraft Engineering Div., War Department, *Oakland, Calif.*

WALKER, JOHN LOOMIS, designing engineer, in charge experimental laboratories, Continental Distributors, Inc., *Chicago.*

WALKER, WILLIAM L., in charge of government department, United States Rubber Co., *New York.*

WARD, HORACE, president, Ward & Company, *Washington, D. C.*

WEEKLY, WILLIAM G., aeronautical engineer, Curtiss Aeroplane & Motor Corp., *Buffalo.*

WERNER, LEO. J., engineer, Splitdorf Electrical Company, *Newark, N. J.*

WHITAKER, FREDERICK P., member law firm Hardy, Stancliffe & Whitaker, *New York.*

WHITE, HERBERT TAYLOR, consulting engineer, Thwaites Bros., Bradford, E. T. White & Co., London, The British Engineering Co. of Russia and Siberia, London and Petrograd, Durham Churchill & Co., Sheffield.

YOUNT, WILLIS HENRY, designer, The Holt Mfg. Co., *Stockton, Cal.*

Book Reviews *for* S. A. E. Members

This section of the S. A. E. JOURNAL is devoted to the technical books considered to be of interest to members of the Society. Such books will be described briefly as soon as possible after their receipt, the purpose being to show concisely the general nature of their contents and to give an estimate of their value.

MANUFACTURE OF ARTILLERY AMMUNITION. By L. P. Alford and others. Published, 1917, by McGraw-Hill Book Co., Inc., 239 W. 39th St., New York. Cloth 6 by 9 in. 765 pages, 699 ill. Price $6.

This book is a compilation of a number of articles that appeared originally in the *American Machinist*. Practically all of them were prepared by members of the editorial staff, although the work of a few contributors has been incorporated in the book. The book constitutes a valuable record of the experience gained by American and Canadian manufacturers in the filling of foreign munition orders.

A paragraph quoted from the foreword by Howard E. Coffin well expresses the need for such information:

"An up-to-date text book, dealing with munitions work, will be found indispensable in this educational campaign (this refers to the work of the Committee on Industrial Preparedness). We have heard much of the difficulties that American manufacturers have experienced in getting out foreign war orders. Months of experimentation, argument and delay have resulted because of the lack of proper information as to the tools, processes and methods involved in the quantity production of such materials. Fortunately for us, we have not been one of the principals involved in the European struggle, and however costly failure in delivery may have been to individual manufacturers, it has not produced a national calamity."

The subject matter is divided into four sections, these taking up shrapnel, high-explosive shells, cartridge cases, and fuse primers. The greatest attention is naturally paid to a description of the manufacturing operations, although in many cases the purpose of the various types of ammunition is explained. Another valuable feature is the matter relating to the physical and chemical composition required of the various metals used for munitions. The book is profusely illustrated with line drawings showing the munitions themselves, as well as jigs and fixtures and other equipment necessary for their manufacture. A large number of photographs are reproduced, showing special machinery used.

The way in which shops built for altogether different purposes were converted into munition plants is one of the interesting points covered in the book. A vast amount of production data are presented, these showing the operations required in making ammunition for England, Russia, France and Serbia.

Among the subjects taken up in the appendix are standardization principles for purchasing machine tools. These were obtained from the experience of the Allied nations, and are of value in industrial preparedness.

LUBRICATION ENGINEER'S HANDBOOK. By John Rome Battle. Published by the J. B. Lippincott Company, Philadelphia. Cloth, 6 by 9 in., 333 pages, 114 ill. Price $4.

The extent of the field covered by the work of the lubricating engineer can best be realized by reading this handbook. Designers of machinery, operating engineers, executives, purchasing agents, oil salesmen, as well as manufacturers of lubricants will find this book contains valuable data applicable to their work.

The theory of lubrication is treated clearly and logically in the first two chapters. Another chapter on the history of petroleum takes up the different crude oils and also considers their properties. The refining processes, both for the tower and the cylindrical apparatus and their operation are explained with the use of diagrams. The "cracking process" is fully described.

The chapter on lubrication oil and grease tests is without doubt the most valuable chapter in the entire book. The methods of making all the common tests are given, and their advantages and disadvantage are outlined. Among the friction testing machine described is the one at the Naval Academy. The author quotes L. Ubbelohde to the effect that for the same conditions the coefficients of friction as determined on these machines are dependent upon the viscosities of the oils alone. The demulsibility test as suggested by the Bureau of Standards is explained.

Three chapters are devoted to general mechanical and electrical engineering data, especially applicable to the lubrication engineer's work. The appendix would seem to be the natural place for these data. The subject of bearing lubrication is presented in a creditable manner. Various bearings are described and sufficient data given for their design. Under methods of lubrication the force, flood and splash systems are taken up. Ball and roller bearings and their lubrication receive due attention. Among the chapters on the general application of lubrication, those on internal-combustion engines would be of the most interest to the automotive engineer. It is to be regretted that these chapters do not contain a more complete treatment of these subjects.

In the chapter on the cost of lubrication valuable information is given in regard to methods of selecting and purchasing lubricants as well as to ways of reducing the friction in shafting and machinery in order to lower the lubrication cost.

The appendix contains general information pertaining to cutting-tool lubrication, storage, oil coolers and cotton waste. Blank forms for recording oil-testing data have been incorporated in the appendix.

TEXTBOOK OF NAVAL AERONAUTICS. By Henry Woodhouse. Published by The Century Company, 353 Fourth Ave., New York. Cloth, 7 by 10 in., 277 pages, 250 ill. Price $6.

This textbook on naval aeronautics is intended to assist in the training of the thousands of airmen that will compose the air fleet that will leave for France in the spring of 1918. Written in a clear, non-technical manner, this book will be of interest to engineers as well as to aviation students. It is really more of a compilation than an original work, and a large number of sources have evidently been drawn upon for material.

The following is a list of some of the subjects covered: Aerial strategy, aerial attacks on ships at sea, the torpedoplane (written by Rear Admiral Fiske), attacking ships with aircraft guns, aircraft mother ships, submarine hunting and location of submerged mines with aircraft, naval anti-aircraft defenses, administration of a naval aeronautic station, rules for flying as issued by

(*Concluded on page 32, Advertising Section*)